ENGINEERING

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ENGINEERING

An Illustrated Weekly Journal

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COASTAL FLOODING

In January last year extensive areas of the eastern shores of England and Scotland, the estuary of the River Thames and much of the Low Countries were flooded by the sea. An unprecedented combination of a fairly high spring tide and a very high surge, their effect increased by a severe wave action, was sufficient for the sea to overtop many of the existing sea and river walls and 160,000 acres of land were flooded; over 300 people lost their lives and 24,000 houses were damaged in the United Kingdom alone. That such a disaster has occurred once is sufficient reason for the necessary works to be undertaken to prevent a repetition.

The evidence suggests that, though the flood was an exceptional occurrence and greater than anything experienced in the previous 350 years, there is likely to be a progressive increase, even if it be slight, in both the heights reached and the frequency of such occurrences. The sea surge had a maximum height of about 9 ft. but this was not the greatest which has been recorded. Fortunately the surge did not coincide with the highest spring tides. Had it done so the water level would have been several feet higher than in fact it was. For over a hundred years there have been progressive increases both in the highest levels reached in exceptional storms and in the frequency with which such levels occur. There has also been a steady rise in the mean sea level relative to the coasts of south-eastern England.

Taking all these facts into consideration, and bearing in mind that the value of land is increasing due to industrialisation and the need for more concentrated farming to meet the demands of an expanding population, it is surprising to find that the Waverley Committee on Coastal Flooding should recommend, as a general practice, a degree of protection no greater than that required to meet the floods of 1953. The committee, set up in April, 1953, to examine the causes of the recent floods, the likelihood of recurrence, the desirable margin of safety for sea defences and the methods of warning to be adopted, have now reported,* setting out their recommendations on the administration and financing of the proposed works and describing a novel method of preventing flooding in the London area.

For the Thames, where the potential damage due to flooding is exceptional, the committee took their deliberations a stage farther than for other parts. They found that it would be impracticable merely to raise the height of the existing defences, since in many places that would involve complete reconstruction. Three other methods were therefore considered. A barrier across the estuary, with gaps through which ships could pass, was thought likely to lead to a deterioration of the estuary. The provision of large areas specially prepared in the lower reaches of the river to receive the excess spill and so reduce the levels higher up was found to be impracticable. The committee therefore propose the building of a barrier across the portion of the river between Purfleet and Greenhithe known as Long Reach; this structure would be provided with "gates" so as to leave the waterway clear except in times of impending high flood. Model tests showed that, given four hours notice of the arrival of the peak of the tide-cum-surge, the maximum water levels at London Bridge could be effectively lowered by about 5 ft. Though the engineering and financial considerations involved are formidable, the committee urge that this suggestion should be further examined in greater detail.

The report draws attention to a number of researches that should be undertaken as preliminaries to the construction of major works for the East Coast generally. The first of these researches relates to oceanographic studies designed to improve the efficiency of the warning system, the aim being to elucidate factors (such as sea levels at remote places) which would allow the development of sea surges to be predicted as far in advance as possible. On the subjects of materials and processes the committee ask particularly for more studies of the behaviour and suitability of grasses and other plants for stabilising sand and shingle banks. The assistance which man-made defences – concrete walls and systems of groynes – can give to the formation of natural defences is another subject requiring further investigation; there is, in this connection, a recognised problem since the concentration of beach material by groynes in one place may well be at the expense of another.

To meet the requirements of both research and design, the committee recommend the fullest co-operation between British and Dutch engineers, scientists and Governments. It is clear, however, that the threat from the sea cannot be met by constructions of gargantuan proportions. The defences will have to be imaginative in conception, carefully related to the vagaries of each locality, and carried out with due regard to æsthetic considerations.

* *Report of the Departmental Committee on Coastal Flooding.* H.M. Stationery Office, Kingsway, London, W.C.2. [2*s.* 6*d.*]

Weekly Survey

GAS AND ELECTRICITY

There are some intriguing possibilities for the engineering industry in the latest announcements of the British Electricity Authority and the Gas Council on their investment programmes for the years up to 1960. Over that period these two industries expect to invest about £1,800 million in new plant and equipment. This amounts to an average annual investment of about £300 million. The global figures were given last week in two booklets, "Power and Prosperity," issued by the B.E.A., and "Fuel for the Nation," issued by the Gas Council. Extracts from these are given on page 774.

The B.E.A.'s plan provides for the installation of nearly 10 million kW of new generating plant in the next six years. The Authority's previous programme was to instal about 7·5 million kW between 1953 and 1957, so it would appear that the rate of investment is to be somewhat increased between now and the end of the 1950's. The average annual investment of £300 million can be compared roughly with the figure of £270 million spent in 1953 on electricity, gas and water combined according to the Economic Survey of 1954. The gas industry will be spending at the rate of about £60 million a year whereas its previous programme allowed for the annual investment of about £45 million a year. Together, therefore, even allowing for the fact that these calculations are only approximations, the gas and electricity industries are going to take a higher proportion of the nation's resources than they have done in the recent past.

Directly, the engineering industry is bound to benefit from increased investment in generating and gas-production plant. Indirectly, these programmes carry two important assumptions for the engineering industry. First, they assume an increased demand which can only be based on higher industrial production in general. Second, there must be a larger allocation of the nation's resources to capital investment by industry as a whole if the share taken by gas and electricity is not to throw the nation's capital investment programme completely out of balance in the next few years. In short, such figures promise both prosperity and a larger allocation of the nation's resources to those goods which the engineering industry makes.

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STILL MORE STEEL

It is remarkable that the demand for steel should have remained so buoyant this year despite curtailment of re-armament production. That it has done so is due to some exceptional influences, but on the whole it testifies to the success of the engineering industry in carrying out its twin task of expanding exports and re-equipping industry at home. In contrast with the United States, where steel production is only about 75 per cent. of what it was a year ago, British output has continued to rise. In May, the third successive month in which a new record has been achieved, it reached 374,500 tons a week – an annual rate of 19·48 million tons. Pig-iron production reached an annual rate of 12·03 million tons—nearly 1 million tons more than a year ago.

The most important of the exceptional influences in this country is, of course, the heavy home demand for motor-cars. The cumulative arrears over the many years when deliveries were restricted have proved to be very considerable. Demand for steel may weaken somewhat when these are made good but, fortunately, export demand for cars continues to rise and should keep steel consumption by the motor-vehicle industry at a high level. Together with the cycle and aircraft industry, the motor-vehicle industry constitutes the largest single steel-consuming group in the United Kingdom. Of the total consumption of steel of 1·16 million tons in the four weeks ending February 27, this group accounted for just over 100,000 tons. It accounted, too, for about 18 per cent. of the increase in steel consumption of 44,000 tons compared with the four weeks to October 31, 1953, the first period following the ending of the steel-distribution scheme for which classified statistics are available.

Another important factor in the higher consumption of steel has been increased demand from contractors to the public corporations. The boiler-makers (partly to meet B.E.A. requirements) raised their consumption in February to 11,100 tons, 1,000 tons more than in October. British Railways consumed 58,000 tons for all purposes, including rolling stock, an increase of 4,000 tons. Some of the increase of 3,900 tons, or 5 per cent. of consumption by constructional engineers, must also be attributed partly to work for the public utilities. The extent of the increase in the output of the engineering industry for the private section of British industry is, however, more difficult to assess. Certainly, consumption of steel by the machine-tool industry and by miscellaneous non-electrical engineering has increased, the latter by about 8 per cent. in February compared with October. This could, however, be accounted for entirely by increased exports. Some industries have actually been consuming less steel. These include textile machinery, shipbuilding, metal furniture, wire-drawing and wire manufacture,

There are thus some weaknesses in the present structure of demand for steel, and it is to be hoped that the investment allowances will increase the consumption of metal manufactures by the private section of British industry over the next few months. Nevertheless the prosperity of British engineering seems in general to be sufficiently well founded to enable the iron and steel industry to achieve a record level of output in 1954.

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EAST GERMAN ENGINEERING

The East German Government announced last week their wish to buy metals and engineering products from the West. A trade delegation of three East Germans, led by Herr E. Senftleben, manager of the Foreign Department of the Leipzig Fair Office, has arrived in this country to meet manufacturers who might be exhibiting at Leipzig next September. The products in which the East German Government are interested include a wide range of iron and steel manufactures, plant and machinery, electrical and optical instruments, as well as building materials, chemicals, agricultural produce and scientific literature. British manufacturers have already booked more exhibiting space at Leipzig than those of any other Western nation except Belgium. At least 40 companies are involved, including Aveling-Barford Limited, British Insulated Callender's Cables Limited and Rubery Owen and Company, Limited. Herr Senftleben said that purchases from Western exhibitors will total £30 million, but gave no indication of how much would consist of engineering products. There is little doubt that many of the products in which there is East German interest will be on the United Nations embargo list, or subject to export licences.

There is at present a very high level of industrial activity throughout Europe. The June issue of the monthly survey of the Bank Deutscher Länder points out a sharp increase in orders received by West German manufacturers for heavy engineering products: "in particular, demand for machine tools, usually an indication of industrial investment, has appreciably increased," and "the fact that building activity is still gaining in momentum has almost become a matter of course." Unemployment is falling and industrial output is expected to rise further. The success of the German Industries Fair at Hanover last month showed how well German engineering has recovered. This is likely to result in increased competition from German companies, such as Humboldt-Deutz, DEMAG and Krupp, during the next few months.

French industrial production has also increased, and in May the index of output had risen to 156, compared to 152 during the first four months of the year. Output is now 75 per cent. higher than a year ago but much of the increase is due to a brisk demand for consumer goods, in sharp contrast with West German trends. France, like the United Kingdom, is suffering from under-investment and prosperity for French engineering companies is sustained by high tariffs and import quotas. There is little doubt that Western Germany's progress is based on much sounder foundations.

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ORDERS FOR SHIPS

There is still little sign of an increase in the flow of orders to British shipyards. The total order book is now not much more than 5 million tons compared with 7 million tons in June, 1952. It is probably too early to expect much from the investment allowances introduced in the last budget; and in view of the vehemence with which shipowners have argued their case for tax remission of this kind, it will be disappointing if they are entirely ineffective in stimulating orders for new tonnage. Nevertheless, their influence alone is unlikely to refill the order books.

Prior to 1914 about half the ships at sea were British-owned; to-day the British merchant fleet accounts for only one-fifth of the world total and a serious fall in the number of British dry-cargo ships has been marked by the large increase in tanker tonnage. The tramp fleet has suffered most. As Mr. R. F. Scovell, the chairman, said in his address to the Intermediate Tramp Section of the U.K. Chamber of Shipping on June 10, "The present situation of British intermediate tramp tonnage can only be viewed with anxiety, and the future faced with apprehension." The total tonnage of intermediate tramps (of 2,000 to 3,000 tonnage) is now only about 150,000 deadweight, 25,000 tons less than a year ago and 350,000 tons less than in 1939. Moreover, a high proportion of the existing fleet is now on offer for sale.

The situation of the intermediate tramp is more extreme than that of other dry-cargo vessels, but all are finding it difficult to show a profit in the face of intensified foreign competition and low freight rates. Two alternatives face shipowners: to let the decay continue, or to build up a new and efficient fleet. At present, unfortunately, the high initial cost of new ships tends to cancel out their advantages in operating efficiency, so there is little inducement to acquire new tonnage.

A readjustment of the relationship between shipbuilding costs and freight rates is thus required. Freight rates have risen a little lately but a major improvement seems unlikely. A fall in shipbuilding costs is equally unlikely; but shipbuilders could help considerably by quoting firm prices so that shipowners, knowing their commitments in advance, would have a better idea of the future profitability of new

ships. Shipbuilders, who lost heavily on fixed contracts placed three or four years ago, may not welcome the risk without some assurance of wages stability. The alternative, however, now that the tanker boom is over, is empty yards and the decline of the merchant fleet.

* * *

SIR CHARLES PARSONS, O.M.

The opening address at the Parsons Centenary exhibition at Newcastle-upon-Tyne on June 14, was given by Professor Aubrey Burstall, president of the Stephenson Engineering Society. The address was entitled "The Place of Sir Charles Parsons in the History of Mechanical Engineering," and Professor Burstall began by saying that the building by Parsons of successful steam turbines marked the beginning of a new era in mechanical engineering. It had been suggested that the last thousand years could be divided into three overlapping periods according to the materials and power employed. The first would be the "wood and water" period from A.D. 1000 to the middle of the Eighteenth Century; the outstanding engineer being da Vinci; the second, the "coal and iron" period, 1700-1900, with James Watt as the chief figure, and the third the "electricity and steel" period. In the last, the development of the turbo-generator caused the greatest industrial change, and for this Sir Charles Parsons was mainly responsible. Many turbines had been planned before his time, but he was the first to make machines capable of delivering power in large quantities. His range of inventions spread far beyond the turbine, however, and included the fields of optics and electricity. He was, moreover, a craftsman and developed a great number of workshop techniques.

Professor Burstall went on to describe the early developments of the turbine before Parsons' time, and told how Parsons' perseverance overcame the many difficulties he encountered. An example quoted was that of the Turbinia, where the low speed actually obtained was found to be due to cavitation at the propellers, and how Parsons cured this. Parsons was the last of the great individual inventors, and team work has now taken charge. The professor called on those present to salute the memory of Charles Algernon Parsons, whom he considered to be one of the greatest mechanical engineers of all time. An appreciation of the life of Sir C. A. Parsons, by Eng.-Capt. E. Smith, was given in our issue of June 11, page 740

* * *

THE BOOM IN CEMENT

The output of cement in this country has been running this year at an annual rate of between 11 and 12 million tons and it is almost certain that 1954 will see a record rate of production. Sir George Earle, chairman of the Associated Portland Cement Manufacturers, Limited, pointed out last week that the normal increase in output has been of the order of 5 per cent. per annum and there is every likelihood that this rate of increase will be sustained for some time to come. The steady advance in cement production is not confined to the United Kingdom. Throughout the world capacity is expanding at an impressive rate both in heavily industrialised countries and in the so-called under-developed areas. Cement capacity in the United Kingdom is expected to increase by something of the order of 1½ million tons between the end of 1953 and the close of 1955 and this expansion is re-echoed throughout the world.

That section of the British engineering industry which specialises in the construction of cement plant and equipment has for long competed successfully in the overseas market against American, German and Danish contractors. So far as the British industry is concerned, a gradual expansion in the U.K. cement industry, such as is envisaged over the next few years, is naturally to be welcomed but British consulting engineers and contractors in the field of cement equipment must have their share of overseas business if they are to be encouraged to keep an adequate proportion of their own capacity available for the production of cement equipment. American contractors, despite their high costs, can offer serious competition in Latin America and in those countries which have received dollar aid. German companies can offer keen prices and attractive credit facilities, and the Danes, through one large company with world-wide ramifications and subsidiaries in many industrialised countries, offer serious competition throughout the world. While the British cement equipment industry will no doubt continue to offer sustained and successful competition in export markets, it is faced with a unique opportunity of contracting for plant in those parts of the Commonwealth and the more under-developed parts of the sterling area, notably in the Middle East, where cement is high on the list of new industries to be developed.

* * *

DEMAND FOR TEXTILE MACHINES

The announcement of a fall of over 30 per cent. in the profits of the English Card Clothing Company in the directors' preliminary statement for the year ended March 31, 1954, is indicative of the difficulties experienced by the textile machinery industry during the past 18 months. The company's results show that the recovery of textile demand which started towards the end of 1952 was not followed by an immediate increase in the purchase of card clothing. There has been some improvement in recent months but there is little hope of a return to the very high level of output of the early 1950's. Deliveries of textile machinery fell sharply in 1953, by more than one-fifth, and the industry's order book was reported to have fallen by a substantially greater margin during the same period. A large order, worth £7 million, was booked last May in Moscow, but this has not been accompanied by a revival of demand in other markets. Exports, which accounted in 1952 and 1953 for about 55 per cent. of total deliveries, show only a slight improvement. Their monthly value, which averaged £3·40 million in 1953, averaged £3·45 million during the first quarter of this year, which represented a 2 per cent. increase on the corresponding period last year.

The news that the Chinese Government are not interested in British textile machines is disappointing but, in April, Mr. Kabanov, the Soviet Minister for Foreign Trade, announced his Government's willingness to negotiate for the placing of orders for £22 million worth of British textile machinery for delivery during the years 1955-57. The £7 million order placed so far consists mainly of spinning, weaving and finishing machines for cotton and worsteds.

The chairman of English Card Clothing pointed out that his company's major difficulties were caused by import restrictions in overseas markets and by growing foreign competition. There are indications, however, that other major exporting countries are also experiencing difficulties, and that they are due to a low level of world demand. Japanese makers' exports in 1953 were 22 per cent. below the 1952 level, and output 25 per cent. below. Several companies were executing armament orders to take up the slack. The American industry is also facing falling orders and an attempt to stimulate demand has been made by one company, the Universal Winding Company of Providence, R.I., by leasing equipment to textile mills.

The considerable growth in the use of synthetic fibres has doubtless affected demand for cotton and wool preparation and spinning machinery. At the same time there is an expanding market for machines to spin staple and to weave and knit the new fibres. Companies who show enterprise and produce first-rate designs backed by energetic selling should do well. One Salford company, the Casablanca High Draft Company, who build high-draft equipment for cotton spinning and preparatory machinery, have recently completed an agreement with the Whitin Machine Works of Whitinsville, Mass. – the largest American builders of spinning machinery – by which their products will be incorporated in the Whitin cardroom and spinning machinery. Even in the processing of traditional fibres, technical excellence and enterprise are likely to pay high dividends.

* * *

TRAINING DRAUGHTSMEN

The rapid growth of the engineering industry and its increasing ramifications have made it a matter of considerable importance that each year a sufficient number of young men should take up engineering as a career. It has not always been easy for some sections of the industry to attract all the men they need to keep pace with this expansion. In particular this has been the case in drawing offices where there has arisen a serious shortage of trained draughtsmen.

It is for this reason that at the Fraser and Chalmers Engineering Works of the General Electrical Company, Limited, a training scheme has been developed to assure a sufficient number of draughtsmen to meet the company's need. Previously, promotion was frequently made by way of the drawing office where young men usually spent part of their apprenticeship. In the past this ensured a constant supply of qualified tradesmen who were glad of the opportunity of training as draughtsmen. Now, however, conditions have changed. Not only is there a shortage of men, but the demands of National Service remove many apprentices immediately they have finished their training in the shops. Accordingly it has been decided to seek out prospective draughtsmen from among the apprentices before they complete their course. Towards the end of their five years' apprenticeship they are transferred to the Drawing Office Training School which was instituted to give, over a period of six months, a thorough grounding in draughtsmanship. As the student gradually gains experience in the training school he inclines ultimately to one or other of the many different branches of mechanical engineering undertaken at the company's works and his training is directed accordingly.

The course of training is not restricted to drawing office practice. As an essential part of his instruction the trainee attends lectures in the work of the various departments. On the completion of his training he is transferred to the drawing office as a junior draughtsman.

While still an apprentice, he is required, like all apprentices, to continue in attendance at a technical college. In the machine shops two courses are open to the apprentice: to study either for the City and Guilds certificate or for the Ordinary National certificate, and this applies also to those who have become trainee draughtsmen. It is intended that, eventually, as many of the trainees as possible shall take the examinations necessary to gain Associate Membership of the Institution of Mechanical Engineers.

A RAMSBOTTOM LOCOMOTIVE

To be Preserved After 89 Years' Service

A locomotive built at Crewe in 1865 by John Ramsbottom, locomotive superintendent of the London and North Western Railway, has been handed over by Imperial Chemical Industries, Limited, to the British Transport Commission for preservation. A short ceremony took place on June 4 at the I.C.I. Kynoch Works, Birmingham. The engine is believed to have been the last locomotive designed by Ramsbottom and was still, until earlier this year, in service. It was originally numbered 1439 in the L.N.W.R. stock, and was sent to Kynoch Limited (predecessors of I.C.I.'s Metals Division) in 1914.

The locomotive was one of the 36 known as the "4-ft. shunters." The most unusual departure from orthodox design is the cylindrical firebox, of the type introduced by Ramsbottom in his 18-in. gauge locomotives employed at Crewe Works (described on page 36 of our first volume in 1866). Later, this type of firebox was used extensively in industrial locomotives constructed by Messrs. W. G. Bagnall, Limited. This firm, in 1935, also built the replacement boiler fitted to the I.C.I. engine. It is identical with that originally fitted apart from strengthening to permit of a working pressure of 160 lb. per square inch, i.e., 20 lb. higher than the original. Cylindrical fireboxes were also employed by Worsdell for some shunting engines built in 1890 and on 21 0-8-0 goods locomotives of the Lancashire and Yorkshire Railway, built in 1903. Basically, the same design re-appeared during the 1939-45 war in boilers built by Krauss-Maffei and fitted to some of the German Class 52 standard war locomotives. The advantages of this type of firebox on contractors' engines were a reduced first cost and ease of renewal; only a single row of rivets required cutting out and the makers claimed that it was possible to replace the firebox in a day. In the case of the L. & Y. boilers, Mr. Hoy, as the result of a boiler explosion on an 0-8-0 engine, wished to avoid water-legs. The motive behind the German use was to save man-hours in production.

Generally, in contractors' and shunting service, where the steam demand was not excessive, the cylindrical firebox gave good results. In main-line service on the L. & Y. the results (presented in 1908 by Mr. G. Hughes in a paper to the Institution of Mechanical Engineers) were disappointing; the fireboxes distorted, the boilers primed badly and the circulation was poor. The German experience was said to be most satisfactory but of course they had the advantages of the considerable progress in metallurgy and welding techniques evolved in the half-century which had elapsed since the L. & Y. experiment.

An important development due to Ramsbottom was the circular bush for coupling rods. Among the early engines to be so fitted were the 4-ft. shunters, but although bushed coupling rods replaced adjustable brasses on nearly all classes of coupled engines on almost all railways, Ramsbottom continued throughout his regime at Crewe to use split brasses on all six-coupled locomotives.

In its present form the engine closely resembles the as-built condition, as will be seen from the illustrations. It has 14 in. by 20 in. cylinders, 4 ft. 1 in. wheels and a weight in working order of 23 tons. There are, however, certain items, small in themselves, which have been changed. The elegant Ramsbottom chimney has been replaced by one of Webb's, the buffers are comparatively modern and the safety valves are not of the type associated with the designer's name.

It is understood that the engine will be preserved at Crewe. Mr. R. C. Bond, Chief Officer (Mechanical Engineering) of the British Transport Commission, expressed his own appreciation and that of the Commission in receiving the engine, and later proceeded – in no uncertain manner – to drive the locomotive to its new ownership. Others present at the ceremony included Mr. J. F. Harrison, mechanical and electrical engineer, London Midland Region; Dr. James Taylor, group director, Metals and Nobel Divisions, I.C.I.; Mr. C. E. Prosser, chairman, Metals Division, I.C.I., who was largely instrumental in presenting the engine to the Commission; and Mr. J. H. Scholes, the Commission's curator of historical relics.

* * *

PERSONAL

SIR HUGH BEAVER, M.I.C.E., M.I.Chem.E., has been appointed chairman of the Advisory Council for Scientific and Industrial Research, in succession to PROFESSOR SIR IAN HEILBRON, D.S.O., D.Sc., F.R.S., who retires on September 30, 1954, on the completion of his term of office.

The President of the Board of Trade has approved the appointment of MR. J. L. GIRLING, a superintending examiner in the Patent Office, as Comptroller-General of Patents, Trade Marks and Designs, in place of the late SIR JOHN BLAKE.

MR. G. H. HARGREAVES, M.C., B.Sc., M.I.C.E., has been promoted to be deputy chief engineer (civil engineering) at the Ministry of Transport and Civil Aviation, in succession to MR. J. F. A. BAKER, M.I.C.E., M.I.Mun.E., A.M.Inst.T., who has been appointed chief engineer, highways, with effect from July 1, next. MR. J. D. W. JEFFERY, T.D., A.M.I.C.E., has been appointed assistant chief engineer at the headquarters of the Ministry, in succession to Mr. Hargreaves.

MR. L. H. G. STERNE has been promoted to the rank of deputy chief scientific officer and appointed Head of the Naval Air Department of the Royal Aircraft Establishment, Farnborough.

MR. F. R. LIVOCK, B.Sc.(Eng.), M.I.E.E., A.M.I.Mech.E., has been appointed sales director to Metal Industries (Electrical Division), Ltd., which includes Brookhirst Switchgear, Ltd., Igranic Electric Co., Ltd., and Cantie Switches Ltd.

MR. N. V. BALDWIN, M.I.E.E., has been appointe managing director of the Brookhirst Igranic S.A (Pty.), Ltd., 19 Link-road, Langlaagte, Johannesburg the South African subsidiary of the group. He ha been connected with the Igranic Electric Co., Ltd., Bedford, for over 40 years.

MR. V. J. CHALWIN, chairman and managing director of Brush Electrical (Australia) Pty., Ltd. and British Oil Engines (Australasia) Pty., Ltd. marketing subsidiaries of the Brush Group, Ltd., in Australia, has resigned with effect from May 31 last. MR. A. P. QUARRELL, A.M.I.Mech.E., A.M.I.Mar.E. has been appointed managing director of Brush Electrical (Australia) Pty., Ltd., and chairman of British Oil Engines (Australasia) Pty., Ltd. MR. J. E. CESTELL, who has been associated with British Oil Engines (Australasia) Pty., Ltd., for 23 years, has been appointed managing director.

MR. S. C. BOND, M.Inst.T., has been appointed President of Traders' Road Transport Association, the national organisation for "C" licence-holders, and chairman of the Association's national council. Mr. Bond succeeds COLONEL ARTHUR JERRETT, M.Inst.T., who has relinquished these posts after nine years, owing to other business commitments. The Association's address is 146 New Bond-street, London, W.1.

COLONEL SIR GEORGE J. CULLUM WELCH, O.B.E., M.C., has joined the board of C. C. Wakefield and Co., Ltd., 46 Grosvenor-street, London, W.1, in succession to MR. HOLLAND YOUNG BLADES, who has served Wakefields since their foundation 55 years ago. Sir George was elected Alderman of the Ward of Bridge in the City of London in 1947 and served as Sheriff in 1950–51. He has been legal adviser to the company for more than 25 years.

MR. J. S. MAKIN has been appointed branch manager of the Manchester office of British Insulated Callender's Cables, Ltd., Norfolk House, Norfolk-street, London, W.C.2. He joined the firm through British Insulated and Helsby Cables Ltd., in 1921.

MR. L. H. GRIFFITHS, F.R.I.C., technical manager of Semtex Ltd., has been appointed assistant general manager to the firm, which is a subsidiary of the Dunlop Rubber Co., Ltd. Mr. Griffiths received a Master's degree in technological science from Manchester University in 1933. His successor as technical manager is MR. WALTER SAUL, who joined Semtex Ltd., in 1942.

MR. J. C. MILNE, M.I.E.E., M.Amer.I.E.E., has been appointed technical director to the Electric Construction Co., Ltd., Bushbury Engineering Works, Wolverhampton.

MR. A. E. GRIMSDALE, B.Sc.(Eng.), special assistant sales manager, Metropolitan-Vickers Electrical Co., Ltd., has been appointed a director of Metropolitan-Vickers Electrical Export Co., Ltd., St. Paul's Churchyard, London, E.C.4.

MR. ARTHUR WHISTON has been appointed sales manager to Stuart Davis Ltd., and is now operating from the company's works at Much Park-street, Coventry. His previous position, in charge of the company's London area, has been taken over by MR. W. K. NORTH.

* * *

BUSINESS CHANGES

SUNVIC CONTROLS, LTD., 10 Essex-street, Strand, London, W.C.2, inform us that the telephone numbers of their works at Harlow, Essex, have been changed to Harlow 24231–5.

The Ramsbottom "4-ft. shunter" which has been handed over by I.C.I. to the British Transport Commission for preservation. It was built at Crewe in 1865 and has a cylindrical firebox. On the left is shown the original form of this class of locomotive and on the right the engine is shown before it was repainted for the handing-over ceremony.

OBITUARY

COLONEL C. M. CROFT

A Distinguished Gas Engineer

We regret to record the death of Colonel C. M. Croft, which occurred in London on Tuesday, June 8, at the age of 67. He had for many years held a leading position in the gas industry and was well known to engineers in that branch, both at home and abroad.

Cyril Murton Croft was born on October 10, 1887, and was educated at Blackheath School. From 1905 to 1908 he served his pupilage with Messrs. H. E. Jones and Sons, consulting engineers, and was afterwards engaged with them as an engineering assistant in the preparation of data relating to gasworks construction for Parliamentary Committees. In 1910 he was appointed assistant district engineer to the Commercial Gas Company, London, but soon afterwards joined the Wandsworth and Putney Gas Company in a similar capacity, in which he continued to act when that concern was amalgamated with the Wimbledon and Epsom District Gas Company as the Wandsworth and District Gas Company.

He was appointed chief engineer in 1918 and combined this position with that of general manager ten years later. During his period of service he was responsible, not only for the technical management of the undertaking, but for the design and construction of all new works. These included a new river wall, one-third of a mile long, and a discharging jetty at Wandsworth, as well as coke grading and screening plant with a capacity of 350 tons per day. He also acted as marine superintendent and carried out investigations on the River Thames between London Bridge and Wandsworth, as a result of which he was able to increase the carrying capacity of the colliers plying between the north of England and the works.

Colonel Croft was elected a Member of the Institution of Civil Engineers in 1935. He became an Associate Member of the Institution of Mechanical Engineers in 1916 and was transferred to the class of members three years later. He was president of the Institution of Gas Engineers in 1945-46 and had served as president of the International Gas Union. He had been managing director both of the Woking and District Gas Company and the Great South London Gas Corporation. He was given the Honorary rank of colonel in the Royal Army Service Corps in 1939.

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We regret also to report the deaths of the following:

MR. CLAUDE JAGO, on May 10, after a long illness. Born at Portocatho, Cornwall, in 1915, Mr. Jago joined Hoover, Ltd., in 1942, as planning engineer at the firm's factory at Perivale, Middlesex. At the time of his death, he was chief development engineer to Hoover (Washing Machines) Ltd., Merthyr Tydfil, Glamorganshire.

MR. TOM MAKEMSON, M.B.E., suddenly, on June 10. He had been secretary of the Institute of British Foundrymen, Deansgate, Manchester, 3, for 27 years. During the war, he served in the Ministry of Supply as director of iron castings in the Iron and Steel Control. In 1927, he was appointed secretary of the Manchester Association of Engineers and served in that capacity for many years. He was awarded the M.B.E. in 1946.

MR. HORACE PERCIVAL SMITH, on June 3, as the result of an accident. Mr. Smith was burnt by molten metal during a demonstration of centrifugal casting at the Sheffield works of Firth-Vickers Stainless Steels Ltd. He had completed 43 unbroken years service with Rolls-Royce Ltd., Derby, having joined the company in 1911 as an office boy. At the time of his death, he was manager of the firm's experimental department.

HONOURS LIST

Many engineers, industrialists and scientists are among those whose names are contained in the Birthday Honours List, published on June 10. Included among them are those mentioned below.

Knights Bachelor

Colonel James G. B. Beazley, M.C., chairman, Mersey Docks and Harbour Board; Richard R. Costain, C.B.E., chairman and joint managing director, Richard Costain, Ltd.; Arnold A. Hall, Director, Royal Aircraft Establishment, Farnborough; Frederick Scopes, President, Joint Iron Council; Francis E. Simon, C.B.E. Ph.D.(Berlin), F.R.S., Professor of Thermodynamics, University of Oxford; Alexander R. Todd, D.Sc.(Glas.), F.R.S., Professor of Organic Chemistry, University of Cambridge, and chairman of the Lord President of the Council's Advisory Committee on Scientific Policy; and Major Arnold H. S. Waters, V.C., C.B.E., M.I.C.E., chairman, South Staffordshire Waterworks Company.

Order of the Bath

G.C.B. Admiral Sir Michael M. Denny, K.C.B., C.B.E., D.S.O.; Sir John G. Lang, K.C.B., Permanent Secretary, Admiralty.

K.C.B. Sir Eric B. Bowyer, K.B.E., C.B., Permanent Secretary, Ministry of Materials.

C.B. Rear-Admiral (E) C. Littlewood, O.B.E.; Major-Gen. W. A. Lord, C.B.E., R.E.M.E.; H. S. Pengelly, principal deputy director of naval construction, Admiralty; Brigadier F. B. Pigott, C.I.E., late Corps of Royal Engineers; Major-Gen. H. H. C. Sugden, C.B.E., D.S.O., late Corps of Royal Engineers; and W. A. Wolverson, Director, External Telecommunications Executive, General Post Office.

Order of Saint Michael and Saint George

K.C.M.G. Major-Gen. L. B. Nicholls, C.B., C.B.E., chairman, Cable and Wireless, Ltd.

C.M.G. Ivor Bowen, principal director of equipment, research and development (air), Ministry of Supply, and formerly Head of the United Kingdom Ministry of Supply staff, Australia; G. Hoyle, divisional inspector of mines, North-Western Division, Ministry of Fuel and Power; J. A. M. Marjoribanks, deputy head of the United Kingdom Delegation to the High Authority of the European Coal and Steel Community, Luxembourg; and Graham Morgan, director of public works, Colonial Engineering Service, Tanganyika.

Order of the British Empire

G.B.E. Air Chief Marshal Sir John W. Jones, K.C.B., C.B.E., R.A.F. (ret'd).

K.B.E. Sir Arthur C. Griffin, formerly chairman of the board of Rhodesia Railways; Rear-Admiral (E) Alexander D. McGlashan, C.B., D.S.O.; Ivan A. R. Stedeford, chairman and managing director, Tube Investments, Ltd., Birmingham.

C.B.E. F. G. G. Carr, Director, National Maritime Museum; F. J. Colvill, engineer-surveyor-in-chief, Ministry of Transport and Civil Aviation; G. E. R. Deacon, Director, National Institute of Oceanography, Wormley, Surrey; Brigadier H. E. C. de Chassiron, late Corps of Royal Engineers; Brigadier H. C. W. Eking, D.S.O., late Corps of Royal Engineers; T. E. Goldup, director, Mullard, Ltd.; G. C. Grove, deputy civil engineer-in-chief, Admiralty; F. H. Harrison, director of equipment and stores, Ministry of Supply; H. G. Herrington, managing director, High Duty Alloys, Ltd., Slough; W. I. Jones, director-general of research, National Coal Board; E. V. Kelley, timber director, Ministry of Materials; Rear-Admiral (E) R. W. Parker; V. A. Pask, chief engineer, British Electricity Authority; Louis Rosenhead, D.Sc., F.R.S., Professor of Applied Mathematics, University of Liverpool; A. E. Russell, director and chief designer, Bristol Aeroplane Co., Ltd., Bristol; Harold Tongue, M.I.Mech.E., for services as chief engineer, Atomic Energy Research Establishment; L. G. Vedy, O.B.E., Assistant Secretary, Ministry of Fuel and Power; H. L. Verry, Assistant Secretary, Department of Scientific and Industrial Research; J. R. Whinfield, for services in the invention of "Terylene"; B. B. Winter, director of engineering, Rootes, Ltd., Ryton-on-Dunsmore, Warwickshire; and W. S. A. Winter, O.B.E., Assistant Secretary, Ministry of Works.

O.B.E. Robert Alexander, assistant works manager, Capenhurst, Department of Atomic Energy; L. R. Barrett, M.B.E., assistant director, Ministry of Supply; Harry Bateman, assistant director of guided weapons (Australia), Ministry of Supply; Alec Broadley, M.B.E., chief executive officer, Marine Division, Ministry of Transport and Civil Aviation; J. B. Brown, manager, Gun-Mounting Department, Vickers-Armstrongs Ltd., Barrow-in-Furness; W. E. Cleaver, manager, Cable and Wireless Engineering School, Porthcurno, Cornwall; F. M. Colebrook, B.Sc., senior principal scientific officer, National Physical Laboratory; A. A. L. Collis, chief engineer, office of the Receiver for the Metropolitan Police District, London; Sydney Constantine, director and general manager, James Dixon and Sons, Ltd., Sheffield; D. A. Evans, assistant director of aircraft engineering, Air Ministry; E. W. Field, managing director, H. W. Ward and Co., Ltd., Birmingham; F. A. Foord, formerly chief technical adviser to the principal director of engine research and development, Ministry of Supply; Frank Grimshaw, general works engineer, Leyland Motors, Ltd., Leyland, Lancashire; W. M. Hampton, technical director and general manager, Chance Brothers, Ltd., Glassworks, Smethwick; Acting Wing Comdr. Frank Herbert, B.Sc., A.M.I.C.E., R.A.F.; Comdr. (E) A. R. Kirk, R.N.; F. C. Lant, deputy chief fuel engineer, Ministry of Fuel and Power; A. W. Lee, formerly deputy chairman, West Midlands Gas Board; F. H. Lister, employer chairman, South Gloucestershire District Advisory Committee, South-Western Regional Board for Industry; M. J. Lithgow, chief experimental test pilot, Vickers-Armstrongs Ltd., Hursley Park; G. M. L. Logie, shipyard manager, Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne; T. W. Mathias, general operations manager, Shell-Mex and B.P., Ltd.; D. L. McLarty, Director of the State Dockyard in New South Wales; J. C. Mitchell, divisional controller, North-Eastern Division, British Electricity Authority; Sydney Ombler, general secretary, Ship Constructors' and Shipwrights' Association; Willie Parkin, superintending examiner, H.M. Patent Office; Captain D. I. Peacock, fleet manager, Stratocruiser and Constellation Fleet, B.O.A.C.; Lieut.-Colonel G. A. O. Perkins, R.E.M.E.; C. H. Perry, chief constructor, Admiralty; Commander (E) W. T. C. Ridley, R.N.; W. H. Sansom, M.C., production director, East Midlands Division, National Coal Board; A. D. Scudamore, M.B.E., principal, Road Transport "A" Division, Ministry of Transport and Civil Aviation; A. T. Smalley, assistant director, Contracts Department, General Post Office; James Smith, secretary, Glasgow and West of Scotland Regional Advisory Council for Technical Education; F. S. Snow, principal, Frederick S. Snow and partners consulting engineers; F. A. Wells, for services in the field of industrial relations; and W. L. Wilson, superintending engineer, Ministry of Works.

M.B.E. C. E. Addis, B.E.M., assistant works manager, Bulpitt and Sons, Ltd., Birmingham; D. L. Brownlow, director and chief engineer, Mirrlees, Bickerton and Day, Ltd., Stockport, Cheshire; M. L. Burgan, experimental officer, Royal Aircraft Establishment, Ministry of Supply; F. N. Calver, engineer-in-charge, Daventry Transmitting Station, British Broadcasting Corporation; R. H. J. Cary, senior experimental officer, Radar Research Establishment, Ministry of Supply, Malvern; Ernest Craddock, director and general manager, West Hunwick Silica and Firebrick Co., Ltd., Willington; E. W. Cross, chief executive officer, Atomic Weapons Research Establishment; Eugene Cross, M.M., personnel manager, Richard Thomas and Baldwins, Ltd., Ebbw Vale; W. J. Dallas, head outside engineer and dock superintendent, Yarrow and Co., Ltd., Glasgow; D. J. P. Davies, superintendent of works, Ministry of Works; F. McW. Galbraith, technical officer (engineering), Ministry of Labour and National Service; W. McA. Gall, manager, Barry Graving Dock and Engineering Co., Ltd., Glamorganshire; Frank Gooch, inspector of works, Air Ministry; D. A. Good, higher executive officer, Naval Construction Department, Admiralty; William Henderson, B.Sc.(Eng.), A.M.I.C.E., main grade engineer, highways engineering staff, Ministry of Transport and Civil Aviation; F. R. Imison, formerly chief personnel manager, Bristol Aeroplane Co., Ltd., Bristol; C. E. Lee-Jones, district engineer, Derby District, East Midlands Electricity Board; R. B. Naylor, chief inspector, F. H. Lloyd and Co., Ltd., Wednesbury, Staffordshire; Gilbert Parker, chief shipbuilding draughtsman, J. Samuel White and Co., Ltd., Cowes; Frank Rostron, export sales manager, Ferranti, Ltd., Hollinwood, Lancashire; J. H. Saunders, assistant electrical manager, Harland and Wolff, Ltd., Belfast; G. C. Scott, manager, naval test department, Evershed and Vignoles, Ltd., London, W.4; A. I. F. Simpson, senior engineer, General Electric Co., Ltd., Coventry; James Smith, industrial relations officer, Lockheed Hydraulic Brake Co., Ltd., Leamington Spa; L. F. Smith, secretary, Longford Engineering Co., Ltd., Bognor Regis; E. N. Southall, director, Joseph Westwood and Son (Cradley Heath), Ltd., Cradley Heath, South Staffordshire; B. E. Sutton, M.I.Mech.E., chief engineer, Thames Valley Traction Co., Ltd.; George Tee, works manager, Fairey Aviation Co., Ltd.; Stockport; F. T. West, principal, Southampton Technical College; and G. W. Wilson, sales director, Belmos Co., Ltd., Bellshill, Lanarkshire.

MORE ELECTRICITY

"A nation's economic progress can indeed be measured by the expansion of electricity supply. The wider use of electricity increases industrial production and raises the standard of life." This quotation has been used as the opening of a booklet entitled "Power and Prosperity" published by the British Electricity Authority, Winsley-street, London, W.1 (1*s*.). If it can be accepted as true, then Britain's prosperity must be assured, for the expansion in the generation of electricity planned for the next few years is very large. Up to 1960, a capital expenditure of £1,421 million is envisaged, with an increase in output of about 10,550,000 kW.

Part of this expenditure will be on the "Supergrid" 275-kV transmission system. This is designed to facilitate the interchange of supplies between districts, as well as for direct distribution. It is estimated that by use of this, new generating stations will be able to be placed nearer the coal sources and this, together with some other considerations, will enable a saving of £5 million a year to be achieved. New stations will tend to follow the present trend of using large generating units, and sets up to 200,000 kW are being designed. One this size is planned for 1959. Operating conditions will also be increased, and temperatures and pressures of 1,000 deg. F. and 1,500 lb. per square inch (using a reheat cycle) are to be employed. Very large boilers will be needed and one now being designed has a capacity of 1,400,000 lb. per hour. Coal will still be the fuel for the greater number of these stations; the use of oil will be avoided if possible, so saving for importation and the risk of atmospheric pollution.

Water power in this country is very limited. Apart from the North of Scotland schemes, and some smaller resources in Wales, very little exists. Tide and wind power are still in the investigation stage.

Nuclear energy is considered to be the best "long term" solution of the fuel problem. Although it is not expected to offer any immediate relief, yet it is hoped that within a few years it will be possible to build a power station using nuclear energy to drive several generating sets, each of 60,000 kW capacity. The required experience will be gained from the small station which is now being built. Within 20 years it may be practicable for nuclear stations to produce electricity in quantities equivalent to the output from 20 million tons of coal. A true comparison of the costs of generation is not yet possible, but the indications are that electricity from nuclear energy may, in the long term, be at a cost competitive to that from coal. The initial cost of plant will be high, however, and will make heavy demands on capital expenditure.

EFFICIENCY GAINS

One of the main aims in present-day power-station design is economy, both in construction and production. Experiments are being made at two stations to reduce building costs by using "semi-outdoor" construction. It has yet to be proved how suitable this will be in the climate of this country, but certainly some saving is possible in this way. Even in orthodox designs, there is a tendency to place some items of plant outdoors. The overall size of plant has also been reduced in relation to its generating capacity.

Economy on the production side is being effected by improved efficiency in the plant. This can be shown by the fact that, while in 1947 1·50 lb. of solid fuel were needed for each unit sent out, in 1953 this was reduced to 1·36. Some of the newer stations are working at thermal efficiencies of better than 30 per cent. This increase in efficiency has a great bearing on the problem of coal supply. Between 1947 and 1953 (five financial years) solid fuel requirements rose 37 per cent. to a figure of 36·2 million tons. The estimated requirement for 1960 is 50 million tons. This forecast is made on existing conditions, and can only be approximate; an increase of ¼ per cent. in the cumulative annual rate of growth of demand would mean another million tons of fuel needed. Thus any slight increase in the efficiency of generation would help to reduce the demand on coal output.

In addition to the Supergrid which will give improved distribution facilities within the country, the cross-Channel project has been shown to be a possibility, see ENGINEERING, page 464 *ante*. The economics suggest that if the two systems could be operated in parallel, both would benefit as peak-load times differ in the two countries. Moreover, any excess generation from French water-power could be used to advantage. The figure of £600,000 is suggested as a possible annual saving by using this link. Distribution in this country is to be accelerated and, for the first time, there is freedom for development in rural areas. The plans for the latter alone involve spending some £130 million and are dealt with fully in a separate booklet published by the Authority entitled "Rural Electrification."

The Electricity Act of 1947 authorised the Authority to raise capital by the issue of stock. At the same time, a limit of £700 million was placed on the amount which could be borrowed at any one time (apart from the purpose of redeeming stock). In addition, of course, the industry has its internal resources which have been supplemented by capital contributions from consumers and some other sources. Thus capital expenditure has to be spread in time, which helps to govern the rate at which new plant can be built and expansion take place.

—AND MORE GAS

That the Gas Council has not been subjected to criticism directed against excessive centralisation, of the type with which the National Coal Board and British Railways are familiar, is almost certainly due to the fact that the Act which nationalised the gas industry in 1949, laid it down that the twelve Area Boards, which together cover the country, should be independent authorities responsible for operation and finance and directly answerable to the Ministry of Fuel and Power. The revenues of the Area Boards are not pooled and each is responsible for production, transmission and distribution.

The Act, however, provided for the establishment of the Gas Council representing the industry as a whole and responsible for capital finance, labour relations and research.

The Council consists of a Chairman, a Deputy Chairman and the Chairmen of the twelve Area Boards. These latter bodies work out their own programmes of development, but any scheme involving substantial capital expenditure has to be approved by the Gas Council. The Act permitted the Council to borrow up to the limit of £250 million for new works, but to cover developments which have been planned to cover the period up to 1960, it is the intention to apply for permission to increase this to £450 million.

In an informative booklet*, the Gas Council has given an account of its stewardship over the last six years and projects of development of the various Area Boards over the next six. At vesting date, the Boards took over undertakings varying in size from "one-man concerns to the Gas Light and Coke Company with some 20,000 employees." The total number of "manufacturing stations" taken over does not appear to be given, but the total for ten of the twelve Area Boards was 842. Many of the small plants were in poor condition and all probably suffered from deferred maintenance due to the war and its aftermath. One of the tasks of the Boards has been interlinking and the closing down of small inefficient plants. As an example of integration the case of the Isle of Wight may be mentioned. It was supplied from six small uneconomic works which were approaching the time for replacement. Their place is being taken by a single works designed to produce 5½ million cubic feet of gas per day.

Details of the many projects and works in hand in other areas are given in the booklet. The overall purpose is to so increase the capacity of the industry that it will be in a position to supply gas with a heat content of 2,924 million therms by 1959–60; the consumption in 1952–53 was 2,524 million therms. The estimate of future demand has been based on an examination of population trends, housing developments and such special factors as industrial developments in new towns. The domestic load is the most important item, exceeding the total of the industrial, commercial and "other" loads. In this phraseology, commercial means offices, hotels and restaurants; "other" means local government departments and canteens and showrooms of the gas industry itself.

In relating the development programme to the estimated demand for gas, it is assumed that the quality of coal will not vary. The general policy is to meet the basic load from carbonising plant and purchases and to cover peaks by water gas and other supplementary supplies. Purchases are mainly from coke ovens of the National Coal Board and iron and steel companies. Supplies, so far on a relatively small scale, have been provided by the tail gases from oil refineries. Although the total amount of gas available between 1953 and 1960 is expected to increase by 15 per cent., an increase of only 6 per cent. in coal consumption is forecast. This is partly due to improved methods of working carbonisation plants and the closing down of inefficient works, but mainly to the increased amount of coke-oven gas which is expected to become available from sources outside the industry and by the installation of carburetted water-gas plant.

As coal is now costing the industry £29 million per year more than it would have cost at the prices ruling at vesting date it is natural that attention should be directed to the possibilities of gas production from sources other than coal. The rapid extension of oil refining in this country has resulted in the marketing of considerable quantities of heavy-oil residues. Diesel oil has been used for many years in the water-gas process, but is now in increasing demand from users other than the gas industry, and attention is being directed to the use of heavy-oil residues as a substitute. It can be used in water-gas plants but in this application it only partly replaces coal, as coal must first be carbonised to provide the necessary coke. It can, however, also be used in special oil-gas plants employing catalysts. Two experimental plants are being operated and show such promise that it has been decided to continue the work on a larger scale. As a possible alternative supply of gas, surveys are to be made to discover any sources of natural gas exist in this country.

* *Fuel for the Nation. The Gas Industry's Programme.* The Gas Council, 1 Grosvenor-place, London, S.W.1. (Price 1*s*.)

Letters to the Editor

DYNAMICAL ANALOGIES
Vibrating Beam and Electric Transmission Line

SIR, In Mr. Yorke's paper "Dynamical Analogies," (ENGINEERING, December 11, 1953, page 763), an analogy is drawn between the vibrating cantilever and the transmission line without specifying the manner in which the cantilever is vibrating.

In calling the device a cantilever one tends to conclude that it is subject to lateral vibrations for which the sectionalised transmission line drawn is certainly not an analogy. The simple equation for the transverse vibration of the cantilever is a fourth-order partial differential equation, whereas that of the line is of second order. The analogy shown is true only for longitudinal vibrations in the bar. A good review of electrical analogies of beams in bending has been given by Russell and MacNeal (American Society of Mechanical Engineers, Paper No. 53-APM-11). The most useful analogies reduce the equations to finite difference form and simulate these electrically.

Incidentally, it is a pity that prominence is usually given to the so-called "direct" analogy as the inverse analogy mentioned in the latter part of Mr. Yorke's paper leads to electrical representations which more nearly represent the mechanical arrangement. Furthermore it overcomes difficulties in the differences, with the direct analogy, between the laws of combination at connection points for the mechanical and electrical systems when there is more than one degree of freedom.

Yours faithfully,
H. M. NELSON,
Officer-in-charge,
Instrumentation Group.

Aeronautical Research Laboratories,
Department of Supply,
Box 4331, G.P.O.,
Melbourne, Australia.
May 21, 1954.

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DRAWINGS IN "ENGINEERING"
Legibility of Back-Lining

SIR, May I reply to yourself, Mr. Tebby, and Mr. Tomlinson (your issues of May 14, page 611; May 28, page 677; June 4, page 707)? When I wrote to you briefly a month ago on this subject, I was unaware even of the name of the convention being used; since then I have asked many experienced engineers about it, and found that most of them were equally ignorant.

Several modern text-books on engineering drawing and also British standard 308: 1953, "Engineering Drawing Practice," fail to mention it. Clearly the convention has not been taught for many years in many courses of engineering drawing, and indeed it is well known that a lot of additional and unnecessary expense may have to be incurred in the preparation of Patent Specifications because of the insistence of the Patent Office on all drawings being "back-lined," a process which few draughtsmen can now perform.

The legibility of anything, whether of a drawing or of someone's handwriting, is largely a matter of experience and practice in interpreting the conventions used. What is essential in engineering drawings is that everyone should use identical conventions, and I repeat and paraphrase my original assertion, which your correspondents have managed to misinterpret, that I found your back-lined drawings less readily legible than the drawings from which they had been prepared.

Five years ago I had to increase the size of a drawing office rapidly by engaging draughtsmen and designers from other firms. I do not think that any two out of the first dozen used identical conventions; is it surprising if unskilled employees are puzzled by the drawings that they have to interpret? What appears to me to be essential is that you, Sir, and every drawing office in the country should stick rigidly to B.S. 308, against which my only serious complaint is that it allows the perpetuation of two different projection and lettering conventions.

Yours truly,
D. B. WELBOURN.

Engineering Laboratory,
University of Cambridge.
June 7, 1954.

SIR, May I suggest that back-lining was discarded before the first World War by the more progressive designers in the motor industry in order to obtain drawings which could be read with the utmost accuracy. This result was best obtained by using lines just thick enough to be seen clearly and therefore capable of defining as correctly as possible most of the thin sections of vital parts used in automobile construction.

In detracting from the art of designing light and efficient machines, back-lining wastes more money by taking longer to do.

Yours truly,
GEORGES ROESCH.

53, Woodlands,
London, N.W.11.
June 2, 1954.

[Other correspondents have urged the retention of back-lining in ENGINEERING as an aid in reading the drawings we publish. Normally an engineering firm's drawing is read by a comparatively small number of people, whereas drawings published in technical journals are examined by a vastly greater number of engineers. In our opinion this seems to justify the extra cost of back-lining.—Ed., E.]

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BUCKLING AND STABILITY
"Snap" Failures of Long Columns

SIR, Professor N. J. Hoff's failure to obtain a "snap" failure in tests with long columns (as described in your report of his Wilbur Wright Lecture, on page 13 of your issue of January 1) is due to the difficulty in obtaining perfect test specimens. It is difficult to avoid slight initial curvature of the strut axis, slight eccentricity in the application of the load, and defects in the homogeniety of the strut. Euler's precise analysis (not the approximation in which the expression for curvature is approximated to the second derivative), certainly predicts the sudden failure at the critical load.

Such a mode of failure has, in fact, been recorded by us in experiments on tied arches. The problem of the tied or the Stabboggen arch, which is parabolic in elevation with the arch rib attached to a rigid chord by means of wire hangers, is fundamentally the same as that of the column. Such snap failures are rare. In the hundreds of experiments conducted by us, Dr. W. G. Godden, M.Sc., A.M.I.C.E., experienced three, and I only one.

Yours faithfully,
CHIN FUNG KEE, M.Sc.,
Formerly Assistant Lecturer,
Queen's University, Belfast.

Drainage and Irrigation Department,
(North Kedah),
Federation of Malaya.
May 15, 1954.

THE INSTITUTION OF METALLURGISTS

In the course of his presidential address delivered before the Institution of Metallurgists at the tenth annual general meeting held in London on June 2, the newly-elected President, Mr. W. Barr, A.R.T.C., chief metallurgist and executive director of Colvilles Limited, Motherwell, Lanarkshire, stated that entry into membership by way of the Institution's examinations was being sought in increasing measure. From the early days, when candidates for examination numbered fewer than 20 to when, last year, there were 240 registered applications representing a twelve-fold increase in about half as many years. For the current year, the registered applications were over 300, which was very satisfactory.

A good many applicants for membership were seeking partial or total exemption from the Institution's examinations. In the case of those submitting metallurgical qualifications awarded by universities, the granting of exemption was provided for in the regulations. Certain other certificates were also acceptable, but there still remained a number of diplomas, the standards of which had yet to be ascertained in relation to known standard examinations or to the Institution examination. A new Board of Metallurgical Studies and Examinations has been set up jointly by the Institution and the Institution of Mining and Metallurgy. The Board's membership represented many interests in metallurgy, and it was now engaged on a review of the standards and requirements of different metallurgical examinations. It was planned that the whole structure of the system of examination and studies would be examined so that there might be found avenues by which any ambitious student could progress to the limit of his capacity and appropriate quotable qualifications be awarded at suitable levels of attainment.

The Institution was playing an increasingly important part in the metallurgical world, not only in the United Kingdom, but in other countries overseas. The scope of its influence was illustrated by the fact that in the recent ballot papers circulated to members in connection with the election of office bearers, returns had been made by the following countries – New Zealand, Australia, South Africa, Canada, India, Pakistan, Malaya, Brazil, Switzerland and Uganda.

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THE INSTITUTE OF MATERIALS HANDLING

The annual dinner of the Institute of Materials Handling, held to coincide with the Mechanical Handling Exhibition, took place on June 12. The chairman, Mr. J. Bright, presided. The principal guest, Colonel the Earl of Onslow, M.C., T.D., D.L., proposed the toast of the Institute. The Institute, he said, now three years old, could and was playing an important part in the survival of our country. We had still the best skills and could still produce designs as good and sometimes better than any other country in the world. By the greater use of mechanical means of handling, our production could be increased and more manpower freed to devote more time to learning and perfecting their skills. The chairman of the Institute, Lord Onslow, remarked, had given him some most interesting figures. In one factory, £83,000 had been saved by new handling methods in one year; in another, £400,000 in three years, and the accident rate in the country had fallen by 10,000 a year. He ended by speaking of his interests in farming and of the need for many new machines in that field.

JOHN I. THORNYCROFT AND CO., LTD.

FIFTY YEARS AT WOOLSTON

The launch, on June 2, of the coastal minesweeper H.M.S. Highburton from the Woolston, Southampton, shipyard of Messrs. John I. Thornycroft and Company, Limited, was an event of more than usual significance in the history of the firm, for it marked also the 50th anniversary of the transfer of their yard from its original location on the Thames, at Chiswick, to the present site.

The business was founded in 1864 by Sir John I. Thornycroft for the purpose of building fast steam launches. This development was contemporary with that of the Whitehead torpedo, and it was on the basis of the design of one of these launches, the Gitana, that Sir John constructed for the British Admiralty the first torpedo boat for the Royal Navy, H.M.S. Lightning, in 1876. Her performance attracted world-wide attention and led to a succession of further orders for torpedo craft for many navies. Eventually, however, the size of such vessels increased so much that it became necessary to find a more spacious site, with a greater depth of water and more convenient access to the open sea.

The site ultimately selected, at Woolston, on the river Itchen, had been a shipyard for many years, mainly for the construction of yachts and small coastal craft, and had been in various hands. Originally it belonged to J. G. Fay and Company, afterwards absorbed in Camper and Nicholsons, Limited, now of Gosport. It was then acquired by T. R. Oswald, of Sunderland, whose business subsequently became Oswald, Mordaunt and Company. After some years, this firm transferred to Milford Haven, where they were reconstituted as T. R. Oswald and Company (Milford Haven), Limited, and the Woolston yard was taken over by Mordey, Carney and Company; but their tenure also was short, and it was left to John I. Thornycroft and Company to set Woolston shipbuilding on a really permanent basis.

The greatly superior possibilities of Woolston by comparison with Chiswick were demonstrated from the outset, the first destroyer to be launched there, H.M.S. Tartar, commissioned in 1907, establishing a world record for her type with a speed on trial of 35·67 knots. For a year or two, both yards were maintained, but eventually the larger construction was concentrated at Woolston and the building of yachts, launches, and similar small craft at Hampton, higher up the Thames. During the 1914-18 war, a remarkable output was achieved, and at one period destroyers of the V and W classes were being handed over to the Admiralty at an average rate of one every eight weeks. This was in addition to various small craft, almost all on Admiralty account, though most of the numerous coastal motor boats – the famous "C.M.B." type – were constructed at Hampton.

Concurrently with an expanding output from Woolston, the shipping industry of Southampton was also expanding rapidly, so that there arose an increasing need for more ship-repairing facilities. These Messrs. Thornycroft were well equipped to provide, and for a number of years they have been responsible for the maintenance of many of the Cunard ships, including the Queen Mary and Queen Elizabeth. A number of outstanding special contracts have also been undertaken by the firm's Repairs Department, prominent among these being the complete reconstruction, following fire damage, of the Furness Withy liner Monarch of Bermuda, now renamed New Australia; the post-war reconditioning of the Orient liner Orontes; and the conversion to a troopship of the ex-German liner Pretoria, now the Empire Orwell.

The Engineering Department, on the transfer from Chiswick, had been laid out for the construction of steam turbines and watertube boilers on a scale adequate to meet the needs of the larger vessels envisaged, and has since been considerably extended. It is still mainly concerned with steam propelling machinery, but oil engines for submarines have also been built, and the foundry, in particular, has undertaken a variety of outside work for makers of textile machinery, food-processing machinery, and hydraulic and chemical-works plant.

Although the firm are principally known as builders of warships, especially torpedo craft, they have had a considerable output of the smaller mercantile vessels such as tugs, coastal passenger vessels and large yachts, shallow-draught river craft, oil barges, and a number of larger passenger and cargo vessels, up to 5,000 tons. To facilitate the repair and maintenance of yachts and the smaller mercantile craft, they took over some years ago the yard at Northam, on the opposite bank of the Itchen, formerly occupied by Day, Summers and Company, which has slipways capable of taking vessels up to 1,000 tons and covered storage space for a number of boats. In recent years, these premises have been extensively modernised and much of the repair work to tugs and coastal craft is now undertaken there.

Work at present in hand at Woolston includes a 6,000-ton tanker for the Peruvian Government, a twin-screw tug for Colombo, a passenger and cargo motorship for the Isles of Scilly Steamship Company, sundry small craft for the Anglo-Saxon Petroleum Company and the Iraq Petroleum Company, and a number of minesweepers for the Royal Navy, of the class to which H.M.S. Highburton belongs. It was understandable, therefore, that there was a definite note of optimism, as well as of achievement, in the remarks with which Sir John E. Thornycroft, K.B.E., the present head of the firm, proposed the toast of "The Ship and her Sponsor" at the luncheon which followed the launch of the Highburton.

H.M.S. "HIGHBURTON"

For security reasons, comparatively few particulars have been released regarding the Highburton, but it may be stated that she is 152 ft. long, with a beam of 28 ft. 9 in., and is constructed almost entirely of wood or other non-magnetic materials. She is the first vessel of her class to be propelled by the "Deltic" type of internal-combustion engine, developed by Messrs. D. Napier and Son, Limited, Acton, London, W.3. This engine, which was described and illustrated in ENGINEERING of May 1, 1953, is of the opposed-piston type, operating on the two-stroke cycle, and has the cylinders arranged in the form of an equilateral triangle in end elevation. It was fitted first in the fast patrol-boat 5212, formerly a German E-boat, and is notable for its compactness in relation to the power developed. This feature is of particular importance since, as Sir John indicated, the coastal minesweepers, of which a large number are being built, have to carry so much electronic and other special equipment in addition to their armament, fuel, stores, etc.

According to the programme, the response to Sir John's toast was to be made by Mr. A. S. Balding, M.C., Southampton manager for the Cunard Steam-Ship Company, on behalf of Mrs. Balding, who had performed the naming ceremony; but, to the pleasure of the assembled guests, Mrs. Balding herself did so, in a speech which was a model of its kind, thus affording Mr. Balding the opportunity to propose the health and future prosperity of John I. Thornycroft and Company, which was honoured with enthusiasm. The only other toast, that of "The Guests," was proposed by the managing director at Woolston, Lieutenant-Commander J. W. Thornycroft, R.N.(ret.), in the absence of Engineer Vice-Admiral Sir Reginald Skelton, K.C.B., and was acknowledged by Mr. A. Dudley, Southampton manager for the Union-Castle Line.

TRADE PUBLICATIONS

Mine Fans. A reprint of a paper entitled "Mine Fans: Some Trends in Present-Day Designs," by Mr. D. MacFarlane, A.M.I.Mech.E., A.M.I.E.E., given before the Association of Mining Electrical and Mechanical Engineers last year, has been issued by Davidson & Co., Ltd., Sirocco Engineering Works, Belfast, N. Ireland.

Carbon Dioxide Plant. The Power-Gas Corporation Ltd., Stockton-on-Tees, have issued an illustrated leaflet describing their "package" carbon-dioxide plant, for producing liquid or gaseous carbon dioxide from oil fuel by the Girbotol process. Two standard sizes are manufactured with capacities of 150 lb. and 300 lb. per hour of carbon dioxide repectively. The units are usually built on a steel baseplate for mounting on a firm level foundation. Alternatively the plant can be supplied mounted on a trailer.

Spray Guns. We have received from the Aerograph Co. Ltd., Lower Sydenham-road, London, S.E.26, an illustrated leaflet giving details of their paint-spray gun, type J.G.A.

Pneumatic Valves, Cylinders and Line Fittings. The Climax Rock Drill and Engineering Works Ltd., Carn Brea, Redruth, Cornwall, have issued an illustrated catalogue of their Maxim pneumatic equipment, covering control valves, cylinders, pipe couplings and adaptors, hose assemblies, etc. Operating diagrams of the valves are explained and specifications are given.

Insulating Concrete. We have received from the Morgan Crucible Co., Ltd., Neston, Wirral, Cheshire, an illustrated broadsheet setting out the properties of MI22 Insulating Concrete, a castable light-weight (85 lb. per cubic foot) low-heat storage concrete which has a maximum service temperature of 2,200 deg. F.

Plastic Oil Containers. A leaflet has been published by the Ideal Machine Tool and Engineering Co., Ltd., 282 Kingsland-road, London, E.8, giving details of the company's transparent plastic oil containers and hand oilers.

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BOOKS RECEIVED

Structural Theory and Design. By J. McHARDY YOUNG. *Crosby Lockwood and Son, Limited*, 26 *Old Brompton-road, London, S.W.7.* (30*s.*) (Previously published in two volumes, and reviewed in ENGINEERING, vol. 171, page 308 (1951), and vol. 174, page 34 (1952).)

The Constitution of Bone China. Part II. Reactions in Bone China Bodies. By P. D. S. ST. PIERRE. Technical Paper No. 7. *Department of Mines and Technical Surveys, Mines Branch, Ottawa, Canada.* (25 cents.)

The Structure of Metals and Alloys. By WILLIAM HUME-ROTHERY and G. V. RAYNOR. Institute of Metals Monograph and Report Series No. 1. Third edition. *The Institute of Metals*, 4 *Grosvenor-gardens, London, S.W.1.* (35*s.*)

Summersons Platelayers' Guide. Seventh edition. *Thomas Summerson and Sons, Limited*, 5a *Dean's-yard, London, S.W.1.* (12*s.* 6*d.*)

Clarke's Tables and Memoranda. A Pocket Compendium of Technical Data for Plumbers, Builders, etc. Tenth edition. *B. T. Batsford, Limited*, 4 *Fitzhardinge-street, Portman-square, London, W.1.* (8*s.* 6*d.*)

Chemical Engineering. Vol. I: Fluid Flow, Heat Transfer and Mass Transfer. By J. M. COULSON and J. F. RICHARDSON. *Pergamon Press, Limited*, 242 *Marylebone-road, London, N.W.1.* (38*s.* 6*d.*)

Report to the President of the Board of Trade by the United Kingdom Industrial Delegation to Burma, March, 1954. *H.M. Stationery Office, Kingsway, London, W.C.2.* (2*s.* 6*d.*)

Industrial Boiler-House Efficiency. By C. F. WADE. *Crosby Lockwood and Son, Limited*, 26 *Old Brompton-road, London, S.W.7.* (15*s.*)

Fork-Lift Trucks. U.S. Case Study Data on Productivity and Factory Performance. Prepared for the Foreign Operations Administration, Industrial and Technical Assistance Division, by the United States Department of Labor. Distributed in Great Britain by the *British Institute of Management*, 8 *Hill-street, London, W.1.* (5*s.*)

5-Horsepower Induction Motors. U.S. Case Study Data on Productivity and Factory Performance. Prepared for the Foreign Operations Administration, Industrial and Technical Assistance Division, by the United States Department of Labor. Distributed in Great Britain by the *British Institute of Management*, 8 *Hill-street, London, W.1.* (7*s.* 6*d.*)

COMPRESSIBLE FLOW OF A SEMI-PERFECT GAS

CHART FOR VARIABLE SPECIFIC-HEAT RATIO

By D. B. Spalding, M.A., PH.D.*

To facilitate the calculation of the compressible flow of a gas it has been common to assume the gas to be perfect, that is to obey the equations

$$p v = \mathrm{R}\,\mathrm{T} \quad . \quad . \quad . \quad (1)$$

and

$$c_p = \text{const.} \quad . \quad . \quad . \quad (2)$$

where p = pressure, v = specific volume, R = gas constant, T = absolute temperature, and c_p = specific heat at constant pressure. Air, the substance of chief practical interest, obeys the first equation very closely, but not the second; for c_p increases with temperature from 0·24 B.Th.U. per lb. per deg. F. at room temperature to over 0·3 B.Th.U. per lb. per deg. F. at high temperatures. It is therefore not permissible to assume that the ratio of the specific heats is constant. Yet when this ratio, k, varies with temperature, the equations of motion cannot be integrated.

In practice the variation of k with temperature is neglected. This permits the derivation of explicit expressions for, for example, the pressure ratio in an isentropic expansion, or the change of density in a shock wave. Many such expressions have been evaluated and tabulated, for example, by Shapiro, Hawthorne and Edelman (1947)* and by Keenan and Kaye (1948)† and most calculations are carried out with the aid of such tables.

The error involved in assuming that k is constant is not significant when the temperature range of the process is small, but may become

* Department of Engineering, University of Cambridge.

* A. H. Shapiro, W. R. Hawthorne & G. M. Edelman, *Jl. Appl. Mech.* vol. 19, page A317, (1947).

† J. H. Keenan & J. Kaye, *Gas Tables*, Wiley, 1948.

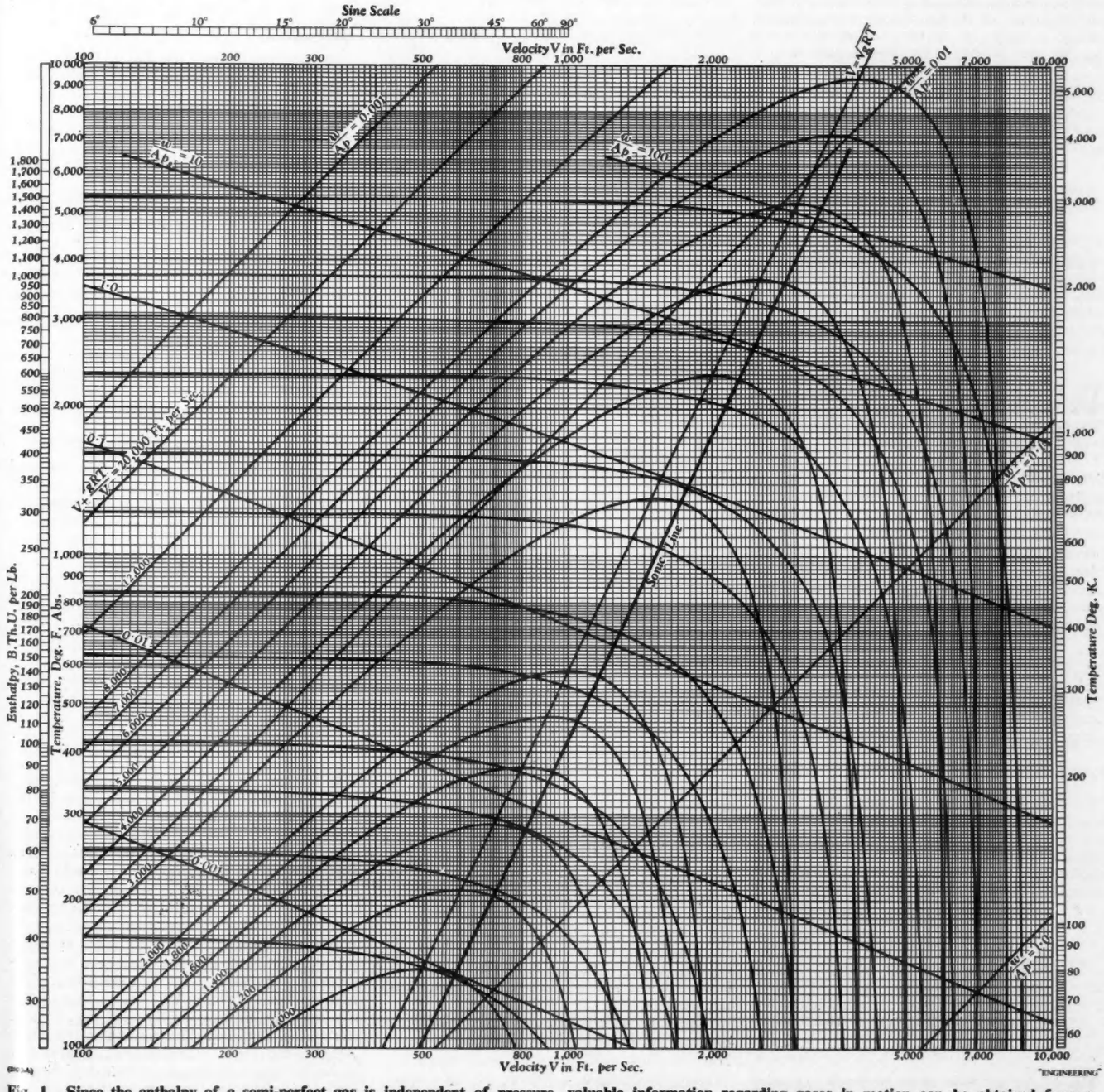

Fig. 1 Since the enthalpy of a semi-perfect gas is independent of pressure, valuable information regarding gases in motion can be obtained from a two co-ordinate graph. The gases are assumed to obey the equation $p v = \mathrm{RT}$ but not c_p = constant. On this compressible-flow chart for air a number of relationships have been plotted with reference to logarithmic co-ordinates of temperature and velocity.

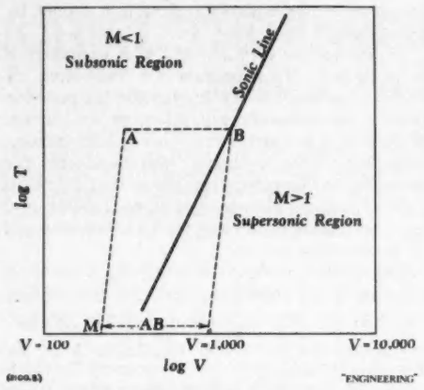

Fig. 2 The Mach number for any given gas velocity can be obtained directly from the chart by measuring on the log V scale the length AB, where A represents the state of the gas and B the sonic velocity at the same temperature.

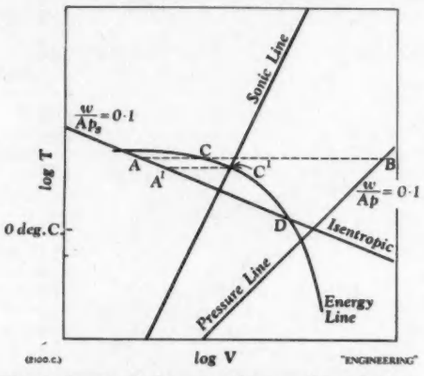

Fig. 3 Isentropic lines enable reversible adiabatic flows to be investigated and information regarding the design of convergent-divergent nozzles may, for example, be obtained.

important at high Mach numbers, where a method of dealing with variable k is desirable. The present article describes a graphical way of doing this. This method has, in addition, the advantages of reduced intermediate computation, of clearly representing the physical considerations involved, and of easy use; it suffers, however, from the limitation on accuracy common to all graphical procedures.

TEMPERATURE-VELOCITY DIAGRAM

Compressible-flow phenomena will be represented on a graph of temperature versus velocity, both plotted logarithmically. Discussion will be restricted to gases which obey equation (1)

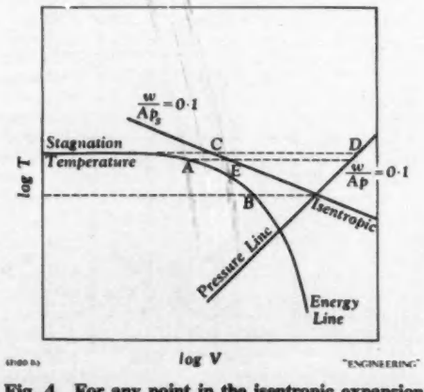

Fig. 4 For any point in the isentropic expansion AB, the mass flow per unit area with a given stagnation pressure can be found from the length AE and CD.

although it is not necessary to make the further restriction that they also obey equation (2).

Graphs are of great convenience in representing the thermodynamic properties of a pure substance, because two properties suffice to determine the state of the substance in the absence of effects due to motion, gravity, capillarity, electricity and magnetism; each point on the graph therefore can represent a state. Here we are concerned with a pure substance in motion, so that three properties must be prescribed, such as pressure, temperature and velocity, to determine the state completely; such a situation calls for a three-dimensional graph. However, it is a characteristic of substances obeying equation (1) that enthalpy and internal energy are pure temperature functions, i.e., they are independent of pressure; while other important magnitudes, such as density or mass flow per unit area, involve pressure only as a simple multiplier. It is possible therefore to obtain important information from a graph in which the third dimension, pressure, is omitted. The ordinate and abscissa of the graph to be used are the logarithms of temperature and velocity respectively.

Fig. 1 shows a log T/log V chart for air, T representing temperature, and V velocity. Since h is a pure temperature function, every horizontal line on the graph corresponds to a particular enthalpy; a vertical enthalpy scale is therefore drawn as well as various temperature scales. The nature of the other curves will now be explained.

Adiabatic flow.—The First Law of Thermodynamics, applied to the adiabatic steady flow of a pure substance without shaft work or effects due to gravity, capillarity, electricity or magnetism, leads to the equation

$$h + \frac{V^2}{2gJ} = h_0, \quad . \quad . \quad (3)$$

where g is the standard gravitational acceleration, J the mechanical equivalent of heat, and h_0 the stagnation enthalpy, i.e., the enthalpy when the stream is brought to rest.

Curves of equation (3) are plotted on the log T/log V chart for various values of h_0, which is represented in each case by the left-hand intersection of the curve with the h-scale; for on the left V is very small so that h and h_0 are practically identical, and the curves are horizontal. The curves droop downwards to the right at the high velocities, for there the enthalpy decreases considerably. Velocity can be read from the logarithmic scales at the bottom and top of the chart. The curves are all similar in shape: if the specific heats of the gas were constant, the curves would be actually identical, differing only in displacement along a direction parallel to the line $T = \frac{V^2}{gR}$. They correspond to Fanno curves (Stodola, 1927) on the Mollier (enthalpy-entropy) diagram, and will here be called energy lines.

Sonic Velocity.—The velocity of sound in a gas obeying equation (1) depends solely on the temperature. A single line representing sonic velocity can therefore be drawn on the log T/log V diagram; this is marked " sonic line " in Fig. 1, for which all data have been taken from the *Gas Tables* of Keenan and Kaye. This line is very nearly straight, and would be quite straight if the specific heats did not vary with temperature.

It may be shown that the sonic velocity, a, depends on temperature in accordance with the law

$$a = \sqrt{k\,R\,T}, \quad . \quad . \quad (4)$$

where k is the ratio of specific heats at the temperature T. The ratio of the actual velocity to the sonic velocity is known as the Mach number M.

$$\frac{V}{a} = M. \quad . \quad . \quad . \quad (5)$$

DIRECT READING OF MACH NUMBERS

Fig. 2 shows how M can be obtained directly from the log T/log V chart. If A represents the state of the gas, the length AB represents log V − log a; when stepped off along an appropriate logarithmic scale, such as the horizontal velocity scale, from the point marked 1 (or 10, 100, etc.), this distance yields Mach number directly. The reason for plotting log V instead of V now becomes clear; the chart avoids subsequent use of the slide-rule by itself incorporating the principles of the slide-rule. It is not usually hard to decide whether AB should be stepped off to the left or to the right. The sonic line divides the chart into two regions: subsonic to the left ($M < 1$); supersonic on the right ($M > 1$).

The pressure line.—If the flow along a duct is steady, the law of conservation of matter leads to the continuity equation

$$\frac{w}{A} = \frac{V}{v}, \quad . \quad . \quad (6)$$

where w = mass flow, and A = cross-sectional area of duct.

Substituting in (6) from (1), we obtain

$$\frac{w}{Ap} = \frac{V}{RT}. \quad . \quad . \quad (7)$$

Since T is a unique function of enthalpy, curves of equation (7) can be drawn for various values of $\frac{w}{Ap}$. They are of course straight lines at an angle of 45 deg. and are drawn in Fig. 1 for $\frac{w}{Ap}$ = 1, 0·1, etc., lb. (mass) per sec., per lb. (force). They are referred to as pressure lines.

The pressure lines may be used to evaluate $\frac{w}{A}$ if the local pressure is known. The distance between the state point and the pressure line is stepped off on a logarithmic scale from the point 1, to the left or right according to the position of the point relative to the line.

Reversible adiabatic flow.—The entropy s of a pure substance is related to the enthalpy and pressure by the equation

$$T\,ds = dh - v\,dp. \quad . \quad (8)$$

This is a consequence of the Second Law of Thermodynamics. In a reversible adiabatic process, $ds = 0$. Substituting in (8) for v with $ds = 0$ from (1) and integrating, we obtain

$$\int_1^2 \frac{dh}{RT} = \log_e\left(\frac{p_2}{p_1}\right). \quad . \quad (9)$$

The integral on the left-hand side has been tabulated for air by Keenan and Kaye (1948). From their data it is possible at every temperature level to step off the horizontal distance corresponding to this integral from any pressure line. Joining these points results in a line which will be called the isentropic. All points on this line are at a horizontal distance from the pressure line corresponding to the logarithm of the ratio of the actual pressure to some other pressure; this other pressure is that prevailing at the intersection of pressure line and isentropic. The isentropics are drawn in Fig. 1 so that they intersect the pressure lines at T = 492 deg. F. abs. (0 deg. C.). In Fig. 3, illustrating this, the length AB gives the ratio of the initial and final pressures in an isentropic expansion to 492 deg. F. abs. from any point at the temperature of A and B, for example that along the energy line connecting C and D; dividers and a logarithmic scale give

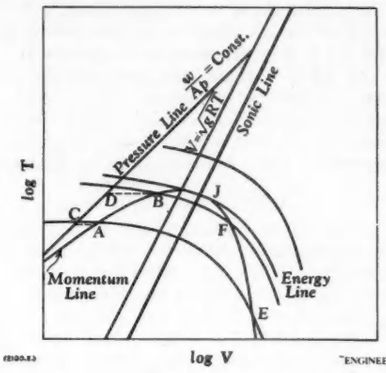

Fig. 5 The change from A to B along a momentum line represents the addition of heat to a flowing gas in a frictionless parallel pipe.

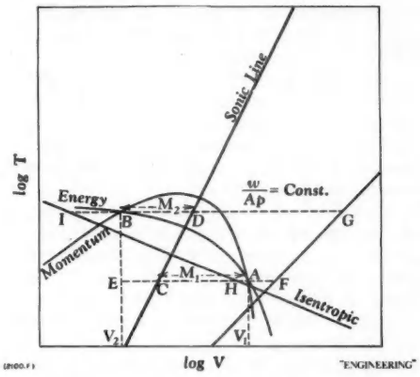

Fig. 6 The points A and B represent states before and after normal shock. Given the upstream conditions those downstream may be found.

this ratio numerically. The choice of 492 deg. is arbitrary, the pressure attained if an isentropic expansion reduces the temperature to 492 deg. will be given the symbol p_s. The isentropics are nearly straight, and would be quite straight if the specific heats were constant, i.e., for a perfect gas.

NOZZLE DESIGN

The horizontal distance between an energy line and the isentropic is significant. In Fig. 3, A B represents $\frac{p}{p_s}$ as we have seen, while B C represents $\frac{w}{A p}$. The distance A C therefore represents $\frac{w}{A p_s}$. The constant value of $\frac{w}{A p_s}$ appropriate to each isentropic is marked on Fig. 1. Since p_s is a constant for a given expansion, A C is proportional to the mass flow per unit area. It is seen that the horizontal distance has a maximum value A′ C′, which occurs at the intersection of the energy line with the sonic line. This means that as the gas expands isentropically from high pressure to low the mass flow per unit area first increases and then decreases, so that the area of the duct must first decrease and then increase. This fact is incorporated in the design of convergent-divergent nozzles. Since the mass flow w is constant along a nozzle the distance A C stepped off along a logarithmic scale can give directly the area of the nozzle at various points in the expansion provided p_s is known.

The pressure after isentropic expansion to the temperature 492 deg. F. abs. is not normally specified, and it is preferable to obtain the value of $\frac{w}{A p_0}$, where p_0 is the stagnation pressure. For any point along the isentropic expansion A B in Fig. 4 the length C D represents $\frac{p_0}{p_s}$, so that $\frac{w}{A p_0}$ is given by A E + C D. This length may easily be stepped off along a logarithmic scale by means of dividers and the mass flow per unit area with a given stagnation pressure can be found for any point of the expansion.

The pressure ratio $\frac{p}{p_0}$ at any point of the expansion is found by stepping of the distance C D − E F. Care is needed in deciding whether to step off to the left or to the right of the 1 of the logarithmic scale, but physical considerations usually make this clear.

Momentum lines.—Consideration of momentum shows that, for flow without friction in a duct of constant cross-section,

$$p + \frac{V^2}{g} = \text{const.} \quad . \quad (10)$$

Introducing the gas law (1) and the continuity equation (6), with w = const., we obtain

$$\frac{R T}{V} + \frac{V}{g} = \text{const.} \quad . \quad (11)$$

ADDITION OF HEAT TO GAS FLOW IN PIPES

Such relations between V and T have been drawn on the log T/log V chart, Fig. 1, for various values of the constant. They correspond to a family of Rayleigh lines (Stodola, 1927) on a Mollier diagram; each line represents the possible states when heat is added to air flowing without friction in a parallel pipe. The lines show the usual characteristics of Rayleigh lines. Starting at the left-hand end, velocity and temperature at first increase together; a maximum temperature is reached when the velocity is equal to $\sqrt{g R T}$, and the temperature diminishes thereafter. At the intersection with the sonic line the slope is the same as that of the energy curve at that point and of the isentropics at that temperature. At the left-hand end the curves are almost parallel to the pressure lines; at the right-hand end the curves slope steeply downwards. The curves will be referred to as momentum lines. They are all identical in shape, differing only in their displacement along the line $V = \sqrt{g R T}$.

Fig. 5 illustrates the addition of heat to a flowing gas in a frictionless parallel pipe, by the change from A to B along a momentum line. The quantity of heat added is measured by the difference of stagnation enthalpy corresponding to the energy curves which pass through A and B. Fig. 5 shows that there is a maximum to the amount of heat which can be added, for energy lines above that passing through the point J do not intersect the momentum line at all. Since the point of tangency, J, is on the sonic line, this means that the maximum heat addition produces sonic velocity at the pipe outlet. Flow through a duct under these circumstances is said to be choked, for no more can pass through. It is interesting to observe that heat addition causes a decrease of temperature when $T < \frac{V^2}{g R} < k T$.

Heat addition in the supersonic region is represented by the change from E to F. In this case both the velocity and Mach number fall, but the temperature rises. Once again heat addition reaches a maximum with the attainment of sonic velocity.

PRESSURE CHANGES RESULTING FROM HEAT ADDITION

Pressure changes result from heat addition. These may be measured on the compressible-flow chart by the change of horizontal distance from a pressure line, since $\frac{w}{A}$ is constant. Thus, in Fig. 5, $\frac{p_A}{p_B}$ is A C − B D stepped off along a logarithmic scale. In subsonic flow heat addition causes a fall of pressure; in supersonic flow it causes a rise of pressure. Cooling of course has the opposite effects. There are also changes of the same sign in stagnation pressure, which may be measured by the procedure outlined above. Heating always reduces the stagnation pressure; cooling always increases it.

SHOCK WAVES

In a convergent-divergent nozzle, the velocity increases steadily as the pressure falls; however, it is not possible to decrease the velocity in an equally continuous way by leading the gas through a similar nozzle in the reverse direction. Instead a discontinuous change occurs which is known as a shock wave. Downstream of the shock the velocity is subsonic, and the pressure is greater than upstream; but the entropy is found to have increased, a sign that the process is irreversible.

Shock waves are of such small thickness that heat losses, wall friction and changes in duct cross-section may be neglected. It follows that equations (3) and (10) both hold; momentum and energy are conserved, although there is a transformation from kinetic to thermal energy. The representation of shock waves on the log T/log V chart will now be discussed.

The Normal Shock.—Fig. 5 shows that, in general, a given pair of momentum and energy lines intersect at two points. Thus two states are possible for a stream of fluid of given stagnation enthalpy and momentum. These states are those which exist on either side of the discontinuous change from supersonic to subsonic velocity which is known as a shock wave.

In Fig. 6 the points A and B represent states before and after a normal shock, respectively. It is usually desired to find the conditions downstream of the shock, the conditions upstream being specified. The downstream velocity V_s may be read directly from the horizontal velocity scale. From the continuity equation, the specific volumes are in the same ratio as the velocities; the distance A E along a logarithmic scale gives this ratio. The Mach numbers M_1 and M_s are measured by A C and B D.

Since $\frac{w}{A}$ has the same value before and after the shock, the pressure ratio $\frac{p_s}{p_1}$ is given by the distance (B G − A F), which may be marked off with dividers along a logarithmic scale; $\frac{p_s}{p_1}$ is, of course, always greater than unity. However, there is always a loss of stagnation pressure; in terms of $\frac{p_{02}}{p_{01}}$, this is measured by the difference between the lengths A H and B I which represent the distances to an isentropic line. When A and B are very close together, which means that the Mach numbers are close to unity, the energy, momentum and isentropic lines have nearly equal slopes; this means that the loss of stagnation

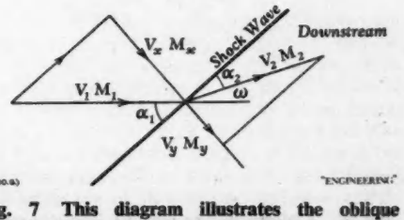

Fig. 7 This diagram illustrates the oblique shock which occurs when a supersonic gas stream is deflected.

pressure in such a shock is very small. The temperature after the shock can, of course, be read directly from the vertical scale.

The Oblique Shock.—When a supersonic gas stream is deflected, for example by solid boundaries, in a direction which causes a pressure rise, a shock wave is formed along a plane which is oblique to the direction of the stream; Fig. 7 illustrates this. The tangential component of velocity parallel to the plane of the wave is unaltered, but the normal component is changed in the way indicated in the foregoing section.

The velocities and angles are related by the expressions

$$\left.\begin{aligned} &\frac{V_x}{V_1} = \frac{M_x}{M_1} = \sin\alpha_1\,;\ \frac{V_y}{V_2} = \frac{M_y}{M_2} = \sin\alpha_2 \\ &V_1\cos\alpha_1 = V_2\cos\alpha_2\,;\ \omega = \alpha_1 - \alpha_2 \end{aligned}\right\}, \quad . \quad . \quad . \quad (12)$$

in which the symbols have the meanings indicated in Fig. 7.

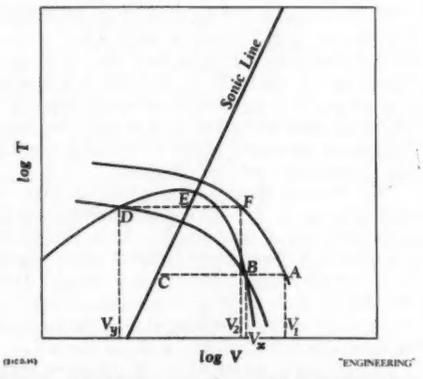

Fig. 8 The point A represents the condition of a gas before entering a shock wave at an angle. F gives the downstream state of the gas.

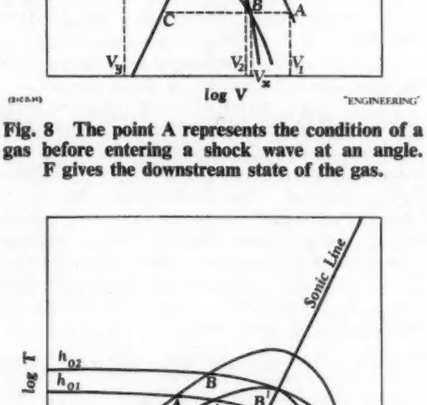

Fig. 9 Changes in density, pressure and Mach numbers across flames can also be obtained from the chart. Deflagration and detonation conditions for normal flames are represented here.

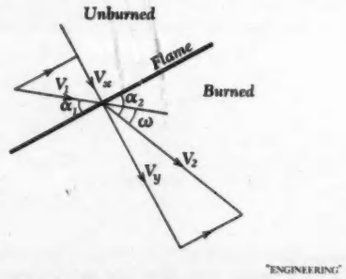

Fig. 10 Oblique flames may be investigated on the chart similarly to oblique shock waves.

LOG-SIN SCALE ON CHART FOR CALCULATING ANGLES

Referring to Fig. 8 we consider a gas stream of condition indicated by point A which enters a shock wave at an angle α_1. The stream Mach number M_1 is given by the distance A C on a logarithmic scale. If B represents the component relative to the shock, the normal Mach number M_x is represented by B C. The distance A B represents $\frac{M_x}{M_1}$ and so is a measure of $\sin\alpha_1$; a scale of log sin α is provided on the compressible-flow chart (Fig. 1) so that α_1 can be immediately determined by means of dividers; B, of course, is on an energy line of lower stagnation enthalpy than A, but at the same actual enthalpy.

Conditions downstream of the shock are represented by the point D which lies on the energy and momentum lines which also pass through B; D E represents the downstream normal Mach number M_1 which is of course less than unity. In the case illustrated the downstream resultant Mach number M_2, represented by E F, is greater than unity, but it is easy to envisage shocks for which F lies to the left of the sonic line. The stream after the shock is represented by F; it lies on the original energy line and is at the same enthalpy level as D. The length D F represents $\sin\alpha_2$. The angle α_2 can be obtained from the log-sin scale and the deflection ω is obtained by subtracting α_1 from α_2.

When the shock wave is inclined to the direction of flow at an angle close to 90 deg., the deflection is correspondingly slight. In this case it is difficult to obtain accurate values of $\alpha_2 - \alpha_1$ from the log T/log V chart, and an analytical method is preferable. Such a method is also without serious error since the variation of k is negligible over small temperature ranges. Values of deflection and other properties of shock waves are tabulated by Keenan and Kaye (1948) for various values of k. The loss of stagnation pressure in such weak shocks is small because the energy, momentum and isentropic lines are all nearly parallel close to their intersection with the sonic line.

COMPRESSIBLE FLOW WITH CHEMICAL REACTION

Where chemical reaction occurs in a flowing medium, there are changes of both mean molecular weight and temperature; both changes affect the specific volume of the fluid. If the specific volume increases on combustion, as is usual, the velocity of flow away from the region of reaction must be greater than the velocity of flow into it. Chemical reaction therefore modifies the pattern of flow.

A reacting gas is not a pure substance in the thermodynamic sense, and a large number of independent properties must be specified, in general, to define its state. Fortunately, however, the region in which reaction actually takes place is normally of small extent compared with the regions filled by totally burned or totally unburned gas, so that only the initial and final mixtures are of significant effect on the flow, the important characteristics of each mixture being the mean molecular weight, and the enthalpy-temperature relation.

As a first approximation, the reactants and combustion products of a reaction can be regarded as having equal molecular weights, and the enthalpy-temperature relations can be regarded as identical except for a constant which is of course the enthalpy change of a constant-temperature reaction, i.e., the calorific value of the mixture. In this case, it is possible to replace the change of composition at constant enthalpy by a change of enthalpy at constant composition, i.e., to treat a flame as a region where a fixed amount of heat is added to a pure substance. When this is done flames can be represented on the log T/log V chart, and compressible flow phenomena can be calculated. This artifice is convenient, and does not normally lead to serious errors. Its artificial nature should however be recognised; a flame is not really a heat addition.

DEFLAGRATION

Normal Flames.—Flames have some characteristics in common with shock waves; they are effectively surfaces of discontinuity in the flow. As with shock waves, flames which are normal to the direction of flow will be considered first. Gas is supposed to flow steadily along a straight pipe; at a certain section the stagnation enthalpy is suddenly increased by a fixed amount, say from h_{01} to h_{02} in Fig. 9. The state upstream of the flame is represented by A, in the subsonic region. The state downstream must therefore be represented by B, which is also subsonic, or by C which is supersonic. The latter possibility is never realised in practice.

The A B type of flame is known as a deflagration. The velocity at which it travels is determined by the nature of the chemical reaction and the thermal conductivity of the gas. In laminar flow it is a constant for a given mixture and initial state.

We have seen above that there is a maximum to the amount of heat which can be added to a gas flowing at a given velocity and temperature. When the heat addition is fixed, as in a flame, there is therefore a maximum steady flame velocity. This is illustrated by the momentum line A′ B′ in Fig. 9.

Flames such as A′ B′ for which the downstream Mach number is unity, are known as Chapman-Jouguet deflagrations (Chapman, 1899*; Jouguet, 1905, 1926†). It is interesting to consider what happens when the flame velocity exceeds that which will produce such a deflagration. There is no known interaction between the fluid dynamics and chemistry which could reduce the chemical reaction to an acceptable rate; there can therefore be no question of the flame being extinguished. The only alternative is that the flame cannot be steady.

DETONATION

If the flame forms in a stream of initially supersonic velocity, such as D in Fig. 9, the downstream conditions might be represented by C. This is, however, unknown in practice. Usually this type of flame is initiated by a shock wave, and the combined shock and flame gives a downstream condition such as that represented by B in Fig. 9. This type of flame is known as a detonation; its velocity of propagation is less dependent on the chemical properties of the gas than is the deflagration. Detonations are little understood and will not be discussed further here.

Changes in density, pressure and Mach number across flames can be measured from the log T/log V chart in the manner indicated in foregoing sections. Deflagration velocities are of the order of only a few feet per second while temperature changes are of the order of 3,000 deg. F. Deflagrations are therefore represented by lengths of momentum line which are normally well to the left of the chart, in the region where the momentum lines are practically straight lines at 45 deg.; pressure and density changes in deflagrations are therefore slight, and the ratios of the velocities upstream and downstream of the flame are closely equal to the ratios of the absolute temperatures.

* D. L. Chapman, *Phil. Mag.*, vol. 47 page 90 (1899).

† E. Jouguet, *Jl. Math.* page 347 (1905); *Proc. Second Int. Cong. Appl. Mech.*, page 12 (1926).

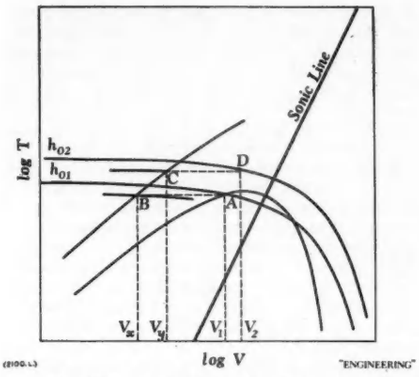

Fig. 11 The relationships found across oblique flames have applications to gas-turbine design.

Oblique Flames.—Flames may be stabilised in gas streams of velocity much greater than the normal velocity of deflagration. This usually involves rather special interference with the flow pattern at the upstream edges of the flame, and elsewhere results in an inclination of the flame to the gas stream. Oblique flames may be represented on the compressible flow chart in a manner similar to shock waves. Fig. 10 shows an oblique flame and the nomenclature to be used. Whereas in a shock wave α_2 is less than α_1, in a deflagration the deflection is towards the normal.

Let A in Fig. 11 represent the combustible gas stream. We suppose that the normal speed of deflagration of the gas, V_x, is fixed. Then B, at the same temperature as A, represents the component of velocity normal to the flame. The distance AB therefore represents sin α_1 when measured on a logarithmic scale; B, of course, is on a lower energy line than A. If the stagnation enthalpy change Δh_0, which represents combustion, is fixed, the normal component of velocity downstream of the flame is represented by C, where $\Delta h_0 = h_{0C} - h_{0B}$. If D lies on the energy line with stagnation enthalpy $h_{0A} + \Delta h_0$ and is also at the same temperature as C, the horizontal position of D gives the resultant velocity V_2 downstream of the flame. C D measures sin α_2. The deflection ω is found by subtracting α_1 from α_2. It is interesting to observe in Fig. 11 that a normal flame of velocity V_1 would have been impossible, the enthalpy change being too great for the Chapman-Jouguet condition; whereas the oblique flame is well away from this limitation.

GAS TURBINES

When the normal flame speed V_x is low, the points B and C may both lie so far to the left on the log T/log V diagram that their respective energy lines are locally horizontal. In this case the above procedure clearly leads to D being vertically above A, i.e. the resultant velocity is unchanged in magnitude ($V_2 = V_1$). This is an extreme to which practical flames approximate quite closely. Of course, $M_2 < M_1$ because the sonic velocity increases with temperature. Such flames have no change of pressure across them. The deflection ω is obtained from considerations of continuity, and is given by

$$\omega = \alpha_2 - \alpha_1 = (\lambda - 1)\frac{V_x}{V_1} \text{ radians}, \quad (13)$$

where $\lambda = \dfrac{V_y}{V_x}$ = the temperature ratio for a constant pressure flame, which in practice is of the order of 5. In a high-velocity combustion chamber, such as a gas-turbine re-heat system, $\dfrac{V_x}{V_1}$ may be of the order of $\dfrac{1}{100}$, so that deflections of only a few degrees may be met with. The flame itself makes an angle of the same order with the incident gas stream. On the log T/log V chart, λ is given by the vertical distance between AB and CD, measured on a logarithmic scale.

MIXING PROCESSES: EJECTORS

In the design of ejectors and other equipment it is often necessary to know the state of the stream formed by the complete mixing of two streams of known state. The length of duct necessary for mixing cannot be determined from thermodynamic considerations alone, but the final state can. Often one stream is supersonic and the other is sonic, and the possibility of shock waves must be considered. Two cases may be distinguished, namely, constant-pressure mixing and constant-area mixing.

In the former the cross-sectional area of the duct is assumed to be varied so that the pressure of the outgoing stream is the same as that of the incoming streams, which are always supposed to be of equal pressure. In this case the conservation of momentum requires that

$$w_1 V_1 + w_2 V_2 = (w_1 + w_2) V_3, \quad (14)$$

where subscripts 1, 2 and 3 refer to the two initial streams and the final stream respectively. The other equation determining the final state is that for the conservation of energy, namely,

$$w_1 h_{01} + w_2 h_{02} = (w_1 + w_2) h_{03}. \quad (15)$$

Equations (14) and (15) fix, respectively, the final velocity V_3, which is between V_1 and V_2, and the final energy line on the compressible-flow chart, which is between the energy lines of the initial streams. The intersection of this energy line and the vertical line for V_3 determines the final state if there is no shock wave. If supersonic velocities obtain in the duct, a shock wave may occur; the state downstream of it may be determined in the way described above.

If, on the other hand, the total area of the duct remains constant, which is simpler for the designer, then the equation of conservation of momentum runs

$$w_1\left(V_1 + \frac{g R T_1}{V_1}\right) + w_2\left(V_2 + \frac{g R T_2}{V_2}\right) = (w_1 + w_2)\left(V_3 + \frac{g R T_3}{V_3}\right), \quad (16)$$

while (15) still represents the conservation of energy in adiabatic flow. In this case therefore the momentum line of the final stream is fixed. It lies between the momentum lines of the two ingoing streams, and its intersections with the final energy line give the two possible downstream states.

Thus, whichever type of mixing is in question, the compressible-flow chart, Fig. 1, enables the state of the resulting stream to be determined. The determination of V_3 or $\left(V_3 + \dfrac{g R T_3}{V_3}\right)$ must be done arithmetically from the mass flows and states of the initial streams. Once the final state point has been fixed on Fig. 1 the new area or pressure, temperature and stagnation pressure can be determined in the way described above.

Finally, the author wishes to acknowledge the assistance of Messrs. Burrows, Wallis, Davis, and Mudd of the Cambridge University Engineering Laboratory staff for assistance in plotting Fig. 1 and its earlier versions.

HEAT CAPACITY OF LAMINATIONS

By L. G. A. Sims and K. L. Morphew

The major thermal properties of the steel core of an electro-magnetic apparatus, upon which the heating and cooling depend, are its heat capacity, its heat conductivity and its heat loss to atmosphere or other coolant. A physical property which determines the heat capacity is the effective specific heat of the stampings. These stampings are coated with appreciable oxide scale formed during the hot rolling process which is an essential part of the manufacture.

Both heat conductivity and heat loss are to some extent under the control of the designer because they depend upon the housing of the stampings, upon whether or not there is forced ventilation and upon what type of heat emitting surface is provided.

It is clear that, of the major thermal properties, the heat capacity of the core is not under the designer's control and this property takes part in determining the core temperature early in a run while the temperature is rising.

A typical high silicon-steel stamping, as used for instance in small transformers, may be about 14 thousandths of an inch in thickness including the surfaces of oxide scale. Considering the specific heat of iron when alloyed with different percentages of silicon, it is known that the specific heat of the alloy rises with the silicon content. The value of 0·13 calories per gram is about correct for a 4 per cent. silicon content and this value can be adopted in forming an estimate of the specific heat at normal temperatures of a typical transformer stamping when coated with oxide scale.

Density figures for silicon-steel sheets are well established in the magnetic-steel industry and the value 7·53 grams per cubic centimetre is quoted by manufacturers as approximately correct for average samples of 4 per cent. silicon steel. This figure can therefore be adopted in conjunction with the specific heat of 0·13 calories per gram for the same steel. Taken together, these two figures give an estimated heat capacity of 0·98 calories per cubic centimetre for the 4 per cent. silicon steel, free of oxide scale.

The oxide scale is reputed to be mainly Fe_3O_4 having a specific heat of about 0·65 calories per gram and a density of 5·25 grams per cubic centimetre giving a heat capacity figure of about 3·4 calories per cubic centimetre. Volume for volume, the scale has therefore a heat capacity which is almost four times as great as that of the alloy. While the scale has thus a much higher heat capacity per unit volume than its parent alloy, its thickness does not appear to be known with certainty. It is stated by manufacturers to be "about one thousandth of an inch on average hot-rolled sheets," which is 7 per cent. of the thickness of a 14-mil stamping. From this it becomes clear that, if we take this figure as an example, Fe_3O_4 scale might be expected to increase the heat capacity of a silicon-steel 14-mil stamping by about 14 per cent. above the value of the same volume of silicon steel when in billet form, or to raise the apparent specific heat from 0·13 calories per gram to 0·15 calories per gram approximately.

Experimental checks upon this figure have been made using a pack of ring stampings of reputed 4 per cent. silicon steel. The mean value (taking J as 4·182 calories per gram) was 0·136 calories per gram (the highest and lowest figures being 0·137 and 0·135). The difference between the theoretically expected figure of 0·15 and the experimentally realised figure of 0·136 represents a discrepancy of 10 per cent. reckoned against the mean of those two figures.

The reasoning above is not greatly affected

by the percentage of silicon because, while the specific heat of the alloy rises with silicon content, its density falls. If the case of pure iron be taken as an extreme example, the specific heat at normal temperature is about 0·11 calories per gram and the density about 7·86 grams per cubic centimetre, giving a heat capacity figure of about 0·86 calories per cubic centimetre (as compared with 0·96 for 4 per cent. silicon steel alloy and with about 3·4 calories per c.c. for the oxide Fe_2O_3).

The differences between the theoretical values for heat capacity calculated in this manner and the values obtained by experiment would therefore seem to turn less upon differences in silicon content than upon the actual thickness and the actual chemical composition of the surface scale.

BRITISH IRON AND STEEL INDUSTRY*

DEVELOPMENTS IN THE PAST 25 YEARS

By Dr. T. P. Colclough, C.B.E., M.MET., F.R.I.C.†

For those at present engaged in the steel industry, with all its activities and wide ramifications, it may sometimes be difficult to realise that the making of steel in bulk began less than 100 years ago and that this survey of development must cover one-quarter of the life of the industry.

It is significant that no vital new principle for the making of iron or steel, or for the rolling and shaping of steel, has been discovered during this last quarter century. The characteristic feature has been the application of scientific knowledge to the industry, based on an intensive study of the principles underlying the processes employed, with a resulting far greater knowledge and better understanding of the operations involved. On the one hand this has led to a marked improvement in the efficiency of the manufacturing processes themselves, a raising of the general standard of quality, and the development of many new types of steel with specialised properties. On the other hand, the inventive genius of the engineering section of the industry has been devoted to the application of scientific knowledge to the development of larger and more efficient units of production; the mechanisation of plant, with its reduction of manual labour; the greater use of electric power to replace steam as the source of energy and to replace raw fuel for melting and other purposes; and the development of instruments to give better control and greater precision to the manufacturing operations and, by reducing the dependence upon human judgment and reaction, to effect a remarkable increase in the speed and accuracy of operation.

These developments have demanded and made possible a complete change in both the general layout and detail of the manufacturing operations, and this in turn has demanded considerable and important changes in the commercial and administrative organisation. It may be of interest to mention briefly a few salient examples of the changes which have taken place.

In 1929 there were roughly 400 blast furnaces in existence in this country. About one-half, or 200 furnaces, had an average capacity of 400 tons per week – totalling together a capacity of, say, 80,000 tons per week. To-day, eight operating furnaces have a capacity of over 50,000 tons per week, and when four other furnaces at present under construction come into operation the 12 furnaces are scheduled to produce 83,000 tons per week.

In steelmaking, the production per open-hearth furnace year has more than doubled, rising from 15,000 tons in 1929 to 39,000 tons in 1953. Electric furnace capacity has risen from about 100,000 tons to over one million tons a year.

In the rolling mills, the growth in number and capacity of the continuous mills has been phenomenal and the capacity of the latest primary rolling units recently brought into operation is roughly four times that of their corresponding units in 1929.

* Seventh Hatfield Memorial Lecture delivered before the Iron and Steel Institute, in London, on Wednesday, May 26, 1954. Abridged.

† Dr. Colclough is Technical Adviser to the British Iron and Steel Federation.

The target for production, three years hence, is 15 million tons of pig iron (practically double that of 1929) and roughly 20·5 million ingot tons of steel, an increase of more than 110 per cent. on 1929, which was at that time an all-time record.

CONDITIONS IN YEARS 1920-29

The years 1920-29 marked one of the most difficult periods in the history of the industry. The artificial demand of the war years 1914-18 had seen the installation of steelmaking and rolling plant far in excess of the normal growth of requirements. Much of the new plant had been built to meet the emergency conditions at relatively high capital cost and was unsuited for normal commercial requirements. In addition, many old units of production, which normally would have been due for scrapping, were retained. As a result of the financial, economic, and industrial conditions after the war, the demand for steel fell away and many plants were either closed down or operated below capacity.

During this 10-year period the imports of steel averaged 2·08 million tons a year, or the equivalent of about 2·6 million tons of ingots. It may be estimated that, in spite of the general state of industrial depression in this country as a whole, the demand for steel averaged about 9·9 million tons a year, but of this amount only 7·36 million tons a year were actually made in this country – 26 per cent. of the steel required was imported.

RECONSTRUCTION

From the practical aspect, the last 25 years fall naturally into three divisions – the pre-war, war, and post-war years. The ten years 1930-39 can be regarded as a period of experiment and tentative progress, the war years were perforce relatively static, and the post-war years have marked a period of rapid and extensive development based on the knowledge and experience gained in the earlier stages.

PRE-WAR YEARS 1929-39

The experience gained in this country and abroad during the years 1920-29 had demonstrated clearly the inherent advantages of integrated operation. The transfer of metal from one operation to the next while still in the liquid or hot condition made possible marked reductions in the cost of fuel and inter-departmental transport. The close association of coke and iron making gave a wider field of application of the valuable coke-oven and blast-furnace gases to the steelworks operations, thereby reducing the demand for raw coal and replacing it by a fuel which could be more readily controlled and more efficiently used.

As a result, certain principles were formulated as a basis for the reconstruction programme. What were the steps taken to implement these principles? While it is clearly impossible to give a detailed account of the many developments that occurred in the ten pre-war years, it is possible to select a few which illustrate the manner in which these principles were applied.

Example 1.—The first of these deals with the position in South Lancashire, one of the centres of wire production. In this area there were blast-furnace plants, steelmakers, re-rolling plants, wire-drawers, and wire fabricators, in total a substantial tonnage. But the different industries were almost totally unco-ordinated and the wire industry in a large measure relied on imports. The economic position of iron and steel works was definitely unsound, and reconstruction of the production units was imperative. To provide a sound basis for reconstruction, it was decided to co-ordinate these industries into a single corporate body – the Lancashire Steel Corporation. The manufacture of pig iron and ferro-alloys was concentrated in the blast-furnaces at Irlam, which were furnished with a new dock, rapid unloading equipment, ore storage yard, and ore crusher. New gas-cleaning equipment was installed at the blast-furnaces, and new coke ovens designed to operate on blast-furnace gas were installed. The steel plant was rebuilt, embodying furnaces of new design with more rapid operation and equipped for the use of mixed gas and liquid fuel. A new continuous rod mill of the latest design was installed at Irlam for the re-rolling of their own billets; the wire rod was transferred to the nearby wire industry at Warrington. This development represented not only the integration of the iron and steel operations, but a complete integration from the raw materials, coal and iron ore, to the finished end product of wire and wire product.

This plant is now in process of being expanded in capacity by about 50 per cent.

Example 2.—Similarly, a number of isolated iron and steel works in South Wales and Scunthorpe were integrated with users of semi-finished steel in South Wales and Birmingham to form the two companies Guest, Keen and Nettlefolds Limited and Guest Keen Baldwins. Their iron and steelmaking operations in South Wales were concentrated in the works at Port Talbot and in a new plant at Cardiff. The new plant at Cardiff comprised a completely integrated manufacturing unit of ore unloading docks, coke ovens, blast-furnaces, steel furnaces, continuous billet mill, and continuous bar, strip, and wire rod mills, together with a mill for the re-rolling of sections suitable for colliery arches, etc.

This plant, designed for a nominal production of 7,000 tons a week, has since the war made and rolled over 15,000 tons of ingots a week and has made the two companies largely self-contained in regard to their steel requirements in these forms.

Example 3.—A third example illustrates another form of plant and company integration. In 1929 the making of steel tubes was carried out by a large number of relatively small, widely scattered companies who relied to a marked extent on tube strip imported from the Continent. After a thorough examination of the possibilities, Stewarts and Lloyds decided to concentrate certain sections of their manufacturing operations in a new plant to be erected at Corby, completely integrated from ore and coal to finished tube. This project involved a combination of new principles, which may be briefly summarised as follows.

The small blast-furnaces were replaced by four new furnaces, up to 20 ft. hearth diameter – larger than it was generally considered possible to operate on Northamptonshire burdens. The whole of the ore was thoroughly graded and the fines were sintered before charging. Coke ovens were installed to provide the necessary coke, and the coals were blended to give the type of coke required.

The whole of the pig iron made was desulphurised before being used for steelmaking. For the steelmaking, the basic Bessemer process, which had gone out of use in 1925, was revived. The rolling mills comprised a semi-continuous slab and billet mill, and a semi-continuous and a fully continuous mill for the rolling of tube strip. The tube mills included a new 40-ft. seamless pipe mill and, a new innovation, the rolling of butt-welded pipe by a fully continuous process.

Simultaneously with the erection of the new plant, the company pursued a policy of commer-

cial amalgamation with a number of other tube-making concerns, so as to give a fully economic load to the new plant and to provide an organisation capable of handling and marketing the whole of the output of the integrated operation.

WAR YEARS

Development during the war years 1939-44 showed quite a different pattern from that in the years 1914-18. In the first war, steel productive capacity was expanded as rapidly as possible, and, as is well known, led to considerable difficulties in post-war years. In the second war it was, for several reasons, deemed expedient to concentrate efforts in this country on the production of vital steels and to provide all possible expansion overseas. The first obvious result was that, whereas the overall steel production in the U.K. in 1918 was 1·87 million tons (or 24 per cent.) higher than in 1913, the maximum steel production during the second war was never substantially above that of the peak pre-war year, 1937.

On the other hand, there was a marked change in the pattern of the quality of steel made. This is demonstrated by two salient factors, the development of electric-furnace production and the increased production of alloy steel. In the years 1937-38 the production of electric steel averaged about 220,000 tons, or 1·9 per cent., of the total steel made. This rose to a peak tonnage in 1943 of 990,000 tons, or 7·5 per cent. of the total production – a fourfold increase.

In addition, a marked contribution to the war effort was made by the change-over of several of the open-hearth steelmakers from ordinary commercial qualities to the manufacture of alloy and special steels. The production of alloy steels rose in 1943 to a peak figure of 1·6 million tons, or over 12 per cent. of the total steel production.

POST-WAR DEVELOPMENT

Before the end of the war, discussions were initiated for the preparation of an agreed development programme. The principles underlying this forward policy and its broad outlines were agreed by December, 1945, and were published in the Command Paper of May, 1946. This document is too familiar to need recapitulation, but it may be of interest to review briefly how far and in what manner the objects set forth in that programme have been attained.

The primary objects of the " Five-Year Plan," of which the principal projects were to be initiated by 1951 and completed by 1953, were: (*a*) To increase steel production to about 15 million tons a year – an increase of 3 million tons (or 25 per cent.) over the pre-war maximum of 1937. (*b*) To install about 5 million tons of iron and steel-making plant of modern, efficient design. (*c*) To install the most efficient design of rolling mills. (*d*) To consolidate production in units of economic capacity and embodying the most recent methods of manufacture.

The production target of 15 million ingot tons was achieved by 1949 and has been surpassed in each succeeding year. It was soon recognised that the target figure, optimistic as it appeared at the time, was not adequate to meet the growing demands of the country. After discussion with the Government departments concerned, it was agreed that the target should be raised to 18 million ingot tons, to be achieved by the mid-1950's. In every year except 1951, when there was a sharp fall in receipts of imported scrap, there has been a substantial increase in production. The production for 1953 was 17·6 million tons, and the present target is for a production of about 20·5 million tons in the years 1957–8.

BLAST-FURNACE SIZE

It is not to be expected that there will be a further marked increase in blast-furnace size in the near future. It is well established that the percentage effective hearth area diminishes as the actual size increases, and it is the general opinion that the optimum size has now been reached for present operating conditions. The crushing and grading of the ore and the sintering of the ore fines are now accepted as essential for the economic operation of the blast-furnace. This practice has grown from practically nil in 1929 to about 9 million tons of sinter capacity for the current year.

The principal features of the steelmaking development have been the increasing dominance of the basic open-hearth process and a marked replacement of acid open-hearth production by electric furnaces, together with the re-introduction of the basic-Bessemer process in two special cases.

While the number of open-hearth furnaces installed has decreased from 595 to 397, the average size of furnace has increased from 55 tons to 95 tons per charge and the production per furnace year from 15,000 tons to 38,870 tons. The development of integrated plants has increased the use of the hot-metal process, and in 1953 practically 80 per cent. of the basic pig iron made was used for steelmaking in the liquid state.

The electric-furnace process, which was in its infancy in 1929, now gives a production of over 1 million tons a year, and individual furnaces of up to 60 tons capacity are under construction. The use of coke-fired crucible furnaces has been almost entirely superseded by the new design of electric induction furnaces.

Production by the basic-Bessemer process has approached 900,000 tons. It is probable that with the new arrangements for blowing with oxygen, with or without steam or CO_2, the production and quality of this type of steel may show marked developments.

ROLLING MILLS

Unfortunately, the lack of statistical data will not permit the same type of assessment of rolling mill development. Nevertheless, this development is real. The striking feature is the increased application of electric drive and of continuous mills, the value of which had been so fully demonstrated before 1929 in the collection of mills at Templeborough.

Primary mills with a capacity of up to 45,000 tons of ingots per week have been installed, and continuous billet mills with rolling capacity of up to 20,000 tons per week have replaced many of the old reversing type mills with a maximum of about 7,000 tons a week.

The outstanding feature in the rolling-mill section is, of course, the development of continuous mills for the hot and cold rolling of sheets and tin-plates. The pioneer installation at Ebbw Vale, with a designed capacity of 500,000 tons a year, represented a complete revolution in the manufacturing process – integration from ore and coal to finished product. The success of this project is apparent and the plant is in process of expansion to 1 million ingot tons a year. The second unit, at Shotton, was first installed in conjunction with the cold-melting shop, and since the war the plant has been converted into a fully integrated unit and the capacity is also being increased to 1 million ingot tons.

The establishment of the central research association, with its band of highly skilled investigators, examining both fundamental principles and works problems, cannot fail to accelerate progress; and the opportunity which it affords within its structure for regular discussion, by the technical personnel of the works and the central staff, of mutual problems and new discoveries has already proved of inestimable value.

THE FUTURE

Competent authorities have estimated that, on the average, provision must be made for an increase of 2½ per cent. per annum in British steel production. In the course of ten years this would amount to over 25 per cent., and, taking the forward view, it is not unreasonable to suggest that the steel production of this country should be raised to about 25 million ingot tons by the middle 1960's.

This prospective increase raises the question of adequate supplies of raw materials. There can be no doubt that new resources of iron ore are available if development is put in hand. This additional ore, in general, is at somewhat greater distances from this country, and additional and improved forms of transport must be provided. It is urgent that steps should be taken immediately by the dock authorities for the further improvement of unloading facilities and the provision of berths for ships of deeper draught in at least four of our principal ore reception ports.

It is evident that the supply of suitable coal will present some difficulties. Here again, research should be concentrated on methods of attaining greater fuel economy, and a study should be made of the possible extension of the use of fuel oil for heating purposes in steelworks.

Annual Meeting of the Iron and Steel Institute (*continued from page* 709)

STEELWORKS PLANT AND PRACTICE

Continuing our report of the annual general meeting of the Iron and Steel Institute held in London on May 26 and 27 we now deal with the afternoon session of May 26.

SOAKING-PIT PRACTICE AT NORMANBY PARK

The first paper considered dealt with " Soaking-Pit Practice at the Normanby Park Steelworks of John Lysaght Ltd." The author, Mr. A. H. Norris, stated that the paper gave the results of three years' experience of working a battery of one of the first post-war installations of one-way top-fired soaking pits. These were heated by a mixture of blast-furnace and coke-oven gas having a calorific value of 135 B.Th.U. per cubic foot. The total air for combustion was pre-heated in refractory recuperators built at the rear of the pits and was delivered to the burners by an electrically-driven hot-air fan, suitable for temperatures of up to 590 deg. C. After careful consideration it had been decided to use coke-breeze bottoms in the pits. Experience had proved that this was a wise policy and the company were very satisfied with the arrangement. Generally speaking the results obtained from the soaking pits had shown that modern advances in instrumentation and construction had a considerable effect on heating efficiency in regard both to heat consumption and the quality of the steel.

DISCUSSION

Mr. S. Thomson, who opened the discussion, said that so far as the pit bottom was concerned, the brickwork was renewed yearly and the breeze bottom lasted from 12 to 14 working days with a consumption of breeze which meant, in effect, an addition of almost 10 per cent. in fuel consumption. It would be interesting to have the author's opinion of the advantage of this type of bottom as against a crushed-dolomite bottom. The soaking pits had now been in operation for three years, and he would be glad to know whether the author had found any falling off in efficiency due to infiltration. It would also be interesting to have the maintenance costs of the pits. One important fact was that, generally speaking, there must always be a fairly large percentage of cold material due to the difference in working shifts in the melting shop and the rolling mills. In view of the fact that recuperative pits were slow heaters of cold material, as the author had shown, had any consideration been given to the possibility of preheating cold material and thereby taking advantage of the undoubted efficiency of the recuperative pits on hot material ?

Mr. W. Ernest said that it might be of interest to present some operating data from a battery of two soaking pits of similar design commissioned at the works of Steel, Peech and Tozer in

1953 as the commencement of a replacement programme. These pits were 22 ft. 6 in. long and 7 ft. 3 in. wide and were rated to hold sixteen 4-ton ingots. In this instance the fuel used was coke-oven gas or oil, and the use of these fuels of high calorific value had brought its own problems, especially in regard to the control of flame and temperature if damage to ingots and refractories were to be avoided. Experience with these furnaces confirmed the excellent results which the author had obtained. The combined coke-oven gas and oil burner used, consisting of a series of concentrically-arranged tubes made of heat-resisting steel, was introduced into the hot-air main which surrounded it. The burner tip terminated approximately 2 ft. behind the pit end wall. Combustion commenced in a circular brick port. In the original design the port diverged conically from a throat diameter of 21 in. The design maximum input rating was 35,000 cub. ft. per hour of coke-oven gas or its equivalent in heavy fuel oil. The divergent port had given rise to difficulties and the port design had been altered to a parallel tunnel 21 in. in diameter.

The pits were now operated with a controlled maximum input of 24,000 cub. ft. per hour of coke-oven gas or 75 gallons per hour of oil, and it was found that the pit was ready for drawing when the fuel input had dropped to 25 per cent. of this maximum. On two further pits about to be installed the control range of the instruments would be reduced in line with the experience gained.

Owing to the location of these pits in the shop, and also to their ability to heat cold ingots rather more uniformly than could the old existing pits, and also, in spite of what Mr. Thomson had said, rather more quickly than the old pits, the percentage of cold charges to the pits was very high. Over the 26-week period from November, 1953, to April, 1954, the relevant performance figures were as follows: output per pit week, 675 tons; percentage of cold ingots, 67·5; over-all fuel consumption, including lighting-up and standby losses for the week, 18·1 therms per ton.

With regard to the refractory life of the side walls, the author managed to keep his ingots standing on their bases. This desirable practice was possible only with top-poured ingots; with uphill-cast ingots it was essential that they should lean against the side. For this reason the provision of a ramp against which the ingots could lean had been found beneficial, since this could be replaced without replacing the whole wall.

Mr. R. Slade said that at the Margam plant of the Steel Company of Wales 33,000 tons of steel were being heated in 20 soaking pits at an overall fuel cost of about 8½ therms per ton.

Mr. W. L. James stated that it must be borne in mind that the real test of a soaking pit was how quickly and how efficiently it could deal with a complete pit of cold ingots. That determined, in the first instance, whether the pit was a good or a bad one. A point on which he had always held strong views was that of the fuel used. After many years of experience, he would prefer to use gas of as low a calorific value as possible, because the least damage was thereby done to the steel and there was the least risk of burning; in addition it was kinder to the refractories.

Mr. A. H. Norris in reply said, on the question of dolomite versus breeze, that he had been responsible for operating dolomite dry bottoms in their previous rolling mills and they dug out the pits every ten weeks or so. He very much preferred breeze to dolomite, although he had had no experience of breeze bottoms before these pits had come into operation. The pits were cleaned out very frequently, every ten days, and they did not get wet bottoms in the pits at all.

They had not taken any steps to preheat cold material, for the simple reason that it had not been necessary. It had been possible to absorb the outputs from the melting shop in a 16-shift week satisfactorily, and when a stock had been built up a 17th shift could always be put on.

With regard to maintenance costs, they were normally under 1*s.* a ton, or approximately 6*d.* a ton. This, however, had now gone up because the lids had been re-bricked. This quite expensive item had been reflected in the maintenance costs during the last six months, and had increased the figure to between 10*d.* and 1*s.* per ton. The necessity to lean against a wall was a nuisance and they were fortunate in being able to stand theirs upright.

PRESENTATION OF PORTRAITS TO THE INSTITUTE

Before proceeding to the next paper, the President announced that Mr. R. W. Evans, of the Steel Company of Wales, Ltd., who had a distinguished father and grandfather, had offered to the Institute paintings of three famous men in the iron and steel industry which had been presented to his grandfather, Mr. William Evans. On the previous day the Council, with great appreciation, had accepted these pictures. They were of Mr. Edward Windsor Richards, a great figure on the North-East Coast and in South Wales for many years; Mr. Edward Williams, also for long a leading man in South Wales; and Mr. William Menelaus, of the Dowlais works, a great figure of about seventy years ago.

WEAR OF GRAPHITE ELECTRODES

A paper describing a co-operative investigation by members of the Electric Process Sub-Committee of the Steelmaking Division of the British Iron and Steel Research Association and research staffs at various steel plants was next considered. It was presented by Mr. F. T. Bagnall and Mr. W. C. Heselwood and was entitled: "Some Factors Affecting the Wear of Graphite Electrodes in the Electric-Arc Furnace." The Sub-Committee stated that spectrographic examination of a sample from a "bad" electrode had shown it to be of a high standard of purity. It therefore seemed that poor quality was not due to the use of unsatisfactory materials. Abnormal wear at the collar of an electrode was usually associated with a high electrical resistivity, and X-ray examination had suggested that this was due to incomplete graphitisation. Simple non-destructive resistivity tests for complete electrodes had been devised and these tests indicated that, in the case of a "bad" electrode, the resistivities of the ends were often higher than that of the middle.

DISCUSSION

Dr. A. H. Leckie, who opened the discussion, stated that the cost of electrodes might be quite a small item in the total cost of a heat of alloy steel, but it was significant for the tonnage steels, and in any case even when making expensive steels there was no excuse for neglecting the opportunity to save several shillings per ton.

The quality of the electrodes, however, was the one item over which the practical steelmaker had least control. Common sense suggested that one of the largest factors governing electrode wear was the surface area of electrode exposed at high temperature. Could the Sub-Committee yet specify the minimum diameter of electrode applicable to any given size of furnace?

Undoubtedly the manufacturers would welcome the suggestion made by the Sub-Committee that electrodes should be tested, because when a good article was produced an acceptance test provided material for good publicity. The paper had concerned itself entirely with graphite electrodes, but it had been suggested on several occasions in the past that substantial savings could be obtained by using paste electrodes of the Söderberg type. The Sub-Committee had been interested in this at one time, and trials might be carried out to confirm whether or not worth-while savings could be made in this country.

Mr. D. H. Houseman said that at the works of K. & L. Steelfounders and Engineers, Ltd., interest had been shown in the relationship between electrode wear and resistivity. Resistivity measurements had been carried out on a batch of a hundred 10-in. diameter electrodes and the batch divided into three groups, having mean resistivities below 900, between 900 and 1,000, and above 1,000 microhm-cm. respectively. The three groups were being successively used for electrode consumption trials in two 5-ton basic electric-arc furnaces; results so far indicated that electrode consumption was directly related to resistivity and it was hoped shortly to report these trials more fully.

Two factors arose in using higher-resistivity electrodes. The first, that of increased wear in the arc, was serious enough from a direct-cost viewpoint, while the second, that of electrode breakage in the furnace, resulted both in wasted electrode ends and in loss of melting time since breakages due to "necking" of the high-resistivity portions of electrodes usually occurred in the early part of the melting cycle. This was due to mechanical stresses set up when the electrodes bore into the scrap; melting conditions were here at their severest and the removal of the broken electrode end was troublesome at this stage. Thus, for reasons both of cost and of convenience, the use of high-resistivity electrodes in the electric-arc furnace was undesirable and they were co-operating with their electrode suppliers in an endeavour to minimise this.

Mr. T. H. Mowbray stated that reference had been made to the question of an acceptance test, but this was difficult to operate. It was a practical impossibility to regraphitise a machined electrode. Electrodes were checked for resistance before they were machined, so that if more than a certain minimum were found to be on the high side for resistance they could be regraphitised; but, having passed the check for resistance after graphitisation, they were machined, and once an electrode had been machined it was difficult to do anything to improve it. At his firm, British Acheson Electrodes Ltd., this method of checking resistance had been changed, but it was still not a practical proposition to check every piece. With a large electrode this would probably be possible, but there were many users who employed 3-in. and 4-in. electrodes, and there were about 150 3-in. electrodes per ton, so that it would add an appreciable item of cost if each one had to be checked. The percentage batch-check system adopted, by and large, operated very well.

Mr. George Wood, speaking as a member of the Sub-Committee which produced the report, considered that Mr. Bagnall had over-emphasised the resistivity and not laid enough emphasis on the surface area. He believed that the surface area had more to do with the loss of electrodes than the resistivity alone, but the two taken together certainly accounted for quite a considerable proportion of the loss. Against that there was the question of trying the Swedish paste electrode, but no one had mentioned trying the amorphous-carbon electrode which was available in this country. He did not know whether any members present had particular reasons for not liking to use the amorphous electrode, but it had been found that just as good steel, or just as bad steel, could be made with amorphous electrodes as with graphite and at a lower cost. The only reason for not using them on the larger furnaces was that the manufacturers could not make the electrode big enough.

Mr. F. T. Bagnall, in reply to Mr. Wood, said that the easiest and most convenient electrode to use was the graphite; personally, he preferred to economise to the limit on the graphite rather than have to use the amorphous-carbon type. With regard to the Söderberg electrode, the question of size was involved. On a 60-ton furnace which his firm were putting in this year 20-in. graphite would be used. If amorphous or Söderberg electrodes were adopted three 36-in. holes would be needed in the arc-furnace roof. He did not think that amorphous-carbon electrodes were made to that size.

Mr. F. Crankshaw, speaking on the question of the use of amorphous-carbon electrodes, said that with the present trend of raising the transformer capacity of small furnaces, it would be difficult. It would be very difficult, as Mr.

Bagnall had suggested, on a 60-ton furnace, but it would be equally difficult with an 8,500-kVA furnace having a shell 8 ft. 6 in. in diameter. Ten-inch electrodes were already in use and, if they were spread out, the arcs would be too near the side walls.

Mr. J. C. Howard took up the question of Söderberg electrodes, stating that it would be agreed unanimously that the graphite electrode was more convenient. If convenience only were considered, graphite would be used; but the question of cost was of major importance, and there was no doubt that the Söderberg electrode was considerably cheaper than the graphite or the amorphous-carbon electrode. This country, however, was competing in world markets and trying to produce steel better and more economically than overseas competitors and the competition of steelmakers abroad who made this steel had to be met. The very fact that a number of Continental makers used Söderberg electrodes made their adoption something which should not be dismissed too lightly in this country. He agreed with Dr. Leckie that development work should be carried out on the Söderberg electrode.

In the paper mention was made of a figure of 25*s.* per ton for the cost of electrodes. It was probably not intended that this should be taken as an indication of what the cost might be. The comparable open-hearth fuel cost was 30*s.* per ton. Anyone who was considering the use of an arc furnace, as an alternative to the open-hearth furnace, might be frightened off by this rather high cost. It was true that 25*s.* per ton was not unknown for the cost of electrodes in some arc furnaces, and the cost could be even more than this, but this high figure was for the high-quality steels, probably of the types made in the crucible furnace. For the wider production of steel a figure of half this price, namely, 12*s.* per ton or even lower, was that which should be mentioned.

Mr. F. T. Bagnall, in a brief reply, said that electrode consumption could be divided into three distinct classes. In the first place there was the graphite which was actually consumed in melting down. Secondly, there was the quantity lost by a mechanical break. Thirdly, there was the amount lost automatically round the nipple when that nipple arrived at the bath surface. With the tapering of the electrode, the collar round the nipple became so thin that it was not capable of holding the nipple or the collar during the melt-down, and pieces were broken off at that stage, so that 60 to 80 lb. might be found in the slag when slagging off.

To be continued

The C.I.G.R.E. Meeting in Paris (*concluded from page* 716)

HIGH-TENSION ELECTRIC POWER TRANSMISSION

IMPULSE WAVES ON TRANSFORMERS

Most of the 16 papers presented in the transformer group at the C.I.G.R.E. Conference dealt with impulse waves. As pointed out in a special report by Mr. R. Langlois-Berthelot (France) it might be thought that everything had already been said on this subject. New methods of detecting and locating faults were, however, being found including those using instantaneous capacitive transmission and chopped waves. In fact, it might now be considered whether the latter method should not become part of the common routine. In connection with the determination of impulse-wave stresses an interesting innovation was the use of scale models to reproduce the capacitance, both to earth and between coils, as well as the inductances and mutual inductances of the coils and the iron structure. The limitation of impulse stresses by the use of semi-conducting blocks and lightning arresters was of fundamental interest to the user, as it allowed the over-insulation of certain parts of the windings to be dispensed with. A new and important question was the breakdown value of the insulation for the various wave shapes which might occur when an external impulse was applied.

The problem of tap-changing on load required careful study from the point of view of the user. Other questions which had received attention were how the thermal stress in the insulation should be determined; how the thermal deterioration of a winding exposed to a given temperature should be ascertained; and how the life of a winding operating at a constant voltage should be estimated.

ON-LOAD TAP CHANGING

A paper entitled "On-Load Tap Changing Equipment," by Mr. E. C. Rippon (Great Britain) was based on a questionnaire circulated by the Study Committee asking for information on the relative merits of one selector switch contact for each tapping; coarse and fine tappings; and a switch arranged for plus and minus operation. Suggestions relating to the maximum range of tappings and maximum and minimum tapping steps were also asked for, as well as information regarding the advantage of using reactor gear of the half-cycle and full-cycle types; the relative merits of resistor cycles; selector and diverter switches; non-linear resistors for restricting the impulse voltage across tap-changer switches; driving mechamism and protection. Reviews of resistor and reactor cycles were included, while the problem of tap-changing under system short-circuit conditions was discussed and the overload capacity of on-load tap changers and the over-voltages arising from current chopping were dealt with. In each case the replies received were analysed and reviewed at length.

DIELECTRIC FATIGUE

In a report on the "Dielectric Fatigue of Insulating Materials and the Maintenance of Electrical Apparatus, particularly Transformers," Mr. R. Langlois-Berthelot (France) said that the problem of studying periodical non-destructive tests of transformer insulation could be divided into two parts: how to recognise by measurement whether the insulation at any given moment was normal or abnormal and how to discover, also by measurement, whether the insulation had aged in a given interval. It was also necessary to determine the ultimate point of permissible ageing beyond which the apparatus should be re-wound or replaced.

Although the study of insulants in all its aspects had been in progress for a number of years in many laboratories the expediency of manufacturers and operating engineers acquiring instruments to enable them to evaluate insulation fatigue was not yet fully recognised. The time, perhaps, was not far distant when means would be available in works for testing incipient ionisation, the mean ionisation current and the maximum discharge current, as well as for making absorption tests which would determine the state of the insulation on delivery. These would not be true reception tests, but would provide criteria for maintenance purposes in the field. The advantages of such tests to the user were not disputed, but their utility would depend on the extent to which they were increased and interpreted.

As regards the relationship of this problem to those which were considered fundamental to the insulation of machines and apparatus, it might be postulated that from the standpoint of insulation all electrical apparatus was characterised by three voltages: that which it could withstand indefinitely (its normal insulation voltage); that which corresponded to the 50-cycle one-minute test, and that which corresponded to the impulse test. Certain relationships between these voltages had been verified by experience, but were only valuable as a guide. The work that had been devoted to the subtleties of the "withstand" voltage was an example. It would be appropriate to devote similar efforts to the question of endurance under a constantly applied voltage. Perhaps it would also be necessary to abandon the 50-cycle test (which was not very logical) in favour of one that was more directly significant, at least for equipment the rating or complication of which would justify this course.

In a paper on "Very High Voltage Network Interconnections – Transformers or Auto-Transformers" Messrs. C. Rossier and J. Froidevaux (Switzerland) pointed out that the substations interconnecting 150/220-kV systems were always equipped with large transformers and the same would be true of future 380-kV networks. The employment of auto-transformers for this purpose had advantages from the points of view of weight, price and lower losses. On the other hand, the conventional transformer gave protection against the transfer of surges from one system to the other. Auto-transformers, too, sometimes gave rise to secondary voltage oscillations, the maximum amplitude of which might exceed that of the primary incident wave. The authors had constructed models to estimate the value of these surges which must be taken into account in deciding the design of the whole installation. The co-ordination of the insulation was only possible if the surges transferred, and even amplified, by the auto-transformer were effectively eliminated.

SYSTEM STABILITY AND FREQUENCY CONTROL

The subjects of system stability and load and frequency control were dealt with in 18 papers, of which we can give only short abstracts of the most important. In a report of the relevant Study Committee, Messrs. S. B. Crary (United States), B. G. Rathsman (Sweden) and R. Robert (France) called attention to the fact that series capacitors and multiple conductors were being increasingly used to reduce the active line reactance. In the United States, further 220-kV capacitors had been placed in circuit and in Sweden a 380-kV installation with a rating of 106 MVA was in operation. Double conductors had been employed on transmission lines erected during the past two years for 220-kV and higher voltages. They were now being introduced on such a line in a tropical climate between the Belgian Congo and Northern Rhodesia. Quadruple conductors were to be employed on the first 380-kV line in Western Germany, which it was expected would be ready about 1957.

The Committee had also been considering how the characteristics of generating sets should be selected so as to impart the most favourable stabilising and regulating properties to the systems to which they were connected. As regards excitation, a report had been made on a modified form of connection for the voltage regulators on a synchronous condenser when subjected to a heavy capacitive load. Automatic re-closing, including single-phase re-closing, was being increasingly used. An examination of the time necessary for de-ionisation at the fault had shown that this normally took place in such a way that a dead interval of 0·25 sec. could be employed for both three-phase and single-phase closing on short line sections. Additional information was, however, needed regarding the de-ionisation time for the heavier currents at higher voltages when using three-phase closing and to determine the conditions for single-phase re-closing on long lines.

380-KV SERIES CAPACITORS

In a paper on "380-kV Series Capacitors in Sweden," Messrs. G. Jancke, K. S. Smedsfelt and P. H. Hjertberg stated that this type of equipment, either alone or in combination with other measures, was the most economical way of reducing the specific transmission costs over a

long line of large capacity. Moreover, it ensured that stability no longer set the limits for power transmission and that the line could be utilised in the most favourable manner from the economic point of view. At the same time, series capacitors enabled the load to be distributed between two circuits in parallel and thus had led to a reduction of the total losses in a complicated network.

As a result of four years' experience with the series capacitors at Alfta the authors were of the opinion that they were a valuable addition to the installation. The future 380-kV lines would be equipped with them, two Curlew conductors per phase being erected at the outset and the arrangements being such that a third conductor could be added later. It was estimated that the greatest economy would be effected with a compensation of 45 per cent. on 500-km. single-circuit lines carrying about 600 MW each. With the triple lines the compensation would be about 60 per cent. with a line of 850 MW per circuit over a distance of 500 km. In a comparison with a system on which capacitors were not used it was pointed out that a reduction of about 15 per cent. in the specific transmission losses would be obtained.

AMERICAN PRACTICE

Messrs. O. A. Demuth and E. J. Harrington (United States) described the "230-kV Series Capacitor Installation on Bonneville Power Administration's System." At Chehalis 24,090 kVAr of series capacitors had been installed and had reduced the tie-line impedance of the 230-kV circuit between two large load areas in Seattle, Washington and Portland, Oregon, a distance of 240 miles. Two larger installations at Rocky Ford (59,400 kVAr) and St. Andrews (36,000 kVAr) had been included between the generating station at Grand Coulee and the load centres at Seattle and Portland to increase the load capacity and had been effective in distributing the load so that it was proportional to the cross-section of the conductors rather than to the natural impedance. Both installations, too, had enabled the construction of additional circuits over the Cascade Mountains to be postponed.

The authors described the economic considerations which had led to the use of series capacitors on these lines and gave details of the operating experiences obtained. They concluded that this equipment was one of the most economical means of increasing the capacity of a high-tension transmission system, especially when that system was heavily loaded. Where the system was expanding rapidly, too, the growth of load and the development of generation might produce changes which could be most economically dealt with by semi-permanent series capacitor installations the positions of which could be altered in accordance with transmission requirements. Equipment was available for protecting the capacitors from faults or excess current. This could be rapidly re-inserted in circuit when the fault had been cleared. The three installations described, two of which were unattended, had required only minor maintenance.

AUTOMATIC FREQUENCY REGULATION

A paper by Messrs. F. Cahen and A. Chevallier (France) on "Automatic Frequency Regulation in Large Networks," discussed methods of regulation which depended, according to the nature and the amount of power regulated, on load-phase regulation (which was equivalent to the frequency regulation of an isolated network); load-phase energy regulation, which depended on the energy of the interconnected networks; and load regulation, which was equivalent to regulating the power between these networks. The industrial possibilities of the first two methods had been demonstrated on the French systems and showed how the regulating power could be increased to any desired extent. As a result, costly telemetering and telecontrol links could be eliminated.

CANADIAN DEVELOPMENTS

In a paper entitled "Load Frequency Control on a Large Interconnected Power System," Mr. C. K. Duff (Canada) said the electrical system in Southern Ontario was supplied from remote water-power stations as well as from thermal stations near the load centres in Toronto and Windsor. In 1948, it was decided to standardise the frequency at 60 cycles, which meant the conversion of nearly all the consumers' equipment, a task which had been about one-third completed. All the new power stations would generate 60-cycle current but about 205 MW of frequency-changer capacity was at present in use. A 60-cycle system had also been built, to which the existing 25-cycle lines were being transferred, and was connected with the system in north-east Ontario.

An office to supervise the operation of the southern system had been in operation since 1942 and the loads of all the major power stations and inter-area connectors were telemetered to it. Separate controls were provided for the 25-cycle and 60-cycle areas, regulation being usually applied at the Niagara Falls (Beck No. 1) station for the former or to the Des Joachim station on the Ottawa River for the latter, or to both when the systems were being operated separately. The north-eastern division had its own control system, which maintained the scheduled load on the interconnection with Southern Ontario by controlling the 25-cycle hydro-electric station at Abitibi Canyon.

Interconnections had recently been made with the Detroit Edison Company between Windsor and Detroit and Sarnia, Ontario and Marysville, Michigan, through 150-MVA voltage-regulating auto-transformers.

After discussing various types of control the author said that the system whereby each individual operating area controlled its own interchange of power was capable of almost indefinite extension in Canada and the United States. Higher standards of control were being sought in order that the maximum use could be made of the interconnectors, especially now that heavy industries were placing larger and more variable loads on the system. To meet these conditions the telemetering and control equipment must operate at the maximum speed and rapid-response gear must be used on the governors, gate and valves.

The contribution of Messrs. R. Keller and W. Frey (Switzerland), on the "Control of the Frequency and Power of Large Networks," dealt with the theory of different systems of control and described their essential features. The optimum control, they said, could be obtained by supplementing continuous action by a system of temporary stabilisation. This problem could be solved by replacing the mechanical speedometer by a frequency meter. The advantages of such a system had been confirmed by its use since 1952 in a Swiss station from which interconnectors ran to a number of different networks.

PNEUMATIC CLAMPS AND FIXTURES

LOCATING LARGE COMPONENTS ON MACHINE TOOLS

To simplify the handling, location and clamping of large workpieces, F. Perkins, Limited, Peterborough, employ a wide variety of air-operated equipment. By means of pneumatically controlled fixtures, such components as cylinder blocks for their high-speed Diesel engines can be set in position for machining in the minimum of time and without the laborious manhandling which would otherwise be involved. Many of the fixtures and handling devices which have been installed are fitted with equipment made by Lang Pneumatic, Limited, Wolverhampton.

In Figs. 1 and 2 can be seen a fixture of this kind used in conjunction with a duplex milling machine, and shown here both open and closed. The cylinder block is placed in the fixture, which has a top clamping beam; a locating device registers the block in the correct position. End clamps are then applied and the work jacks are locked. The beam, which is operated by a trunnion mounted air-cylinder, is lowered and secured, and finally the main clamps on top of the fixture are tightened by hand.

The sequence of operations is governed by pneumatic equipment, and air pressure also provides the force for clamping and securing the components during machining operations. In Fig. 3 can be seen the layout of a system for controlling the clamping fixture of the duplex milling machine. It is typical of many others.

AIR-CIRCUIT FOR CLAMPING FIXTURE

To initiate the cycle, the hand-operated valve *a* is placed in the forward position; this applies air to the automatic valves *b* and *c*. The piston of cylinder *d* performs its inward stroke and when

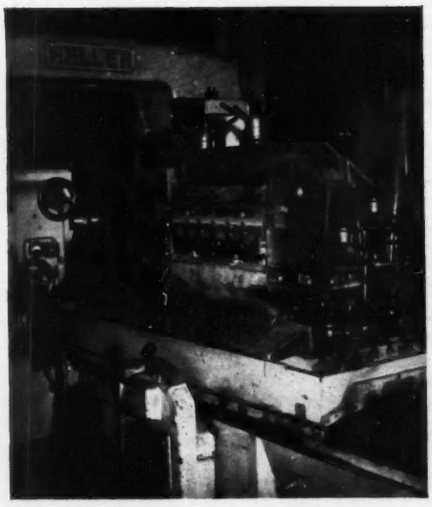

Fig. 1 The cylinder block on this miller is clamped by a pneumatically controlled fixture.

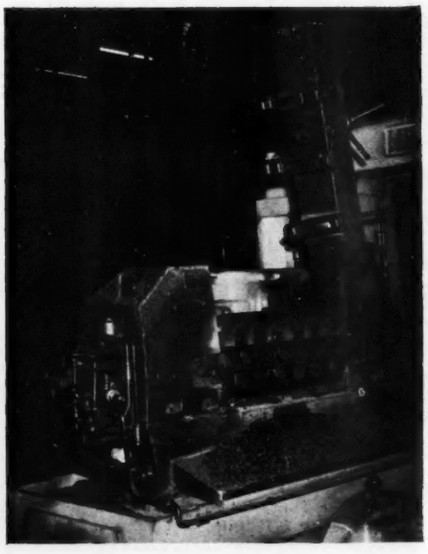

Fig. 2 The swinging top beam operated pneumatically is shown here in the open position.

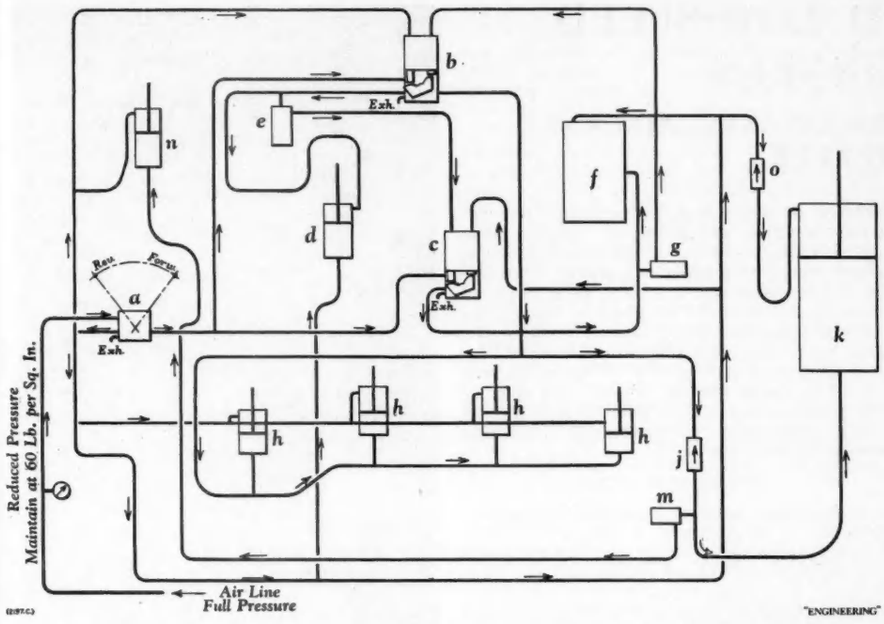

Fig. 3 In the fixtures described in this article, air pressure not only provides the clamping force but also controls the sequence of clamping operations. The pneumatic system represented here diagrammatically is used in conjunction with a milling-machine fixture.

it has completed its travel, the unloader valve *e* lifts and reverses valve *c*, thus supplying air to cylinder *f* and causing the outward displacement of the piston. Unloader valve *g* lifts and reverses valve *b*, which transmits air to the four cylinders *h*, moving their pistons outwards; this supply of air is throttled through the air-flow regulator *j* to cylinder *k*, which operates in the same manner. Unloader valve *m* then lifts and forces out the piston of cylinder *n*, thus completing the forward cycle.

The return cycle is set in motion by reversing the hand-control valve *a*, thus supplying air to the cylinders *d*, *f*, *h* and *n*, which are restored to their initial positions. This supply of air is also throttled through the regulator *o* to cylinder *k*, causing the inward displacement of the piston, and is finally transmitted to the automatic valves *b* and *c*, which are thus reset for the next cycle.

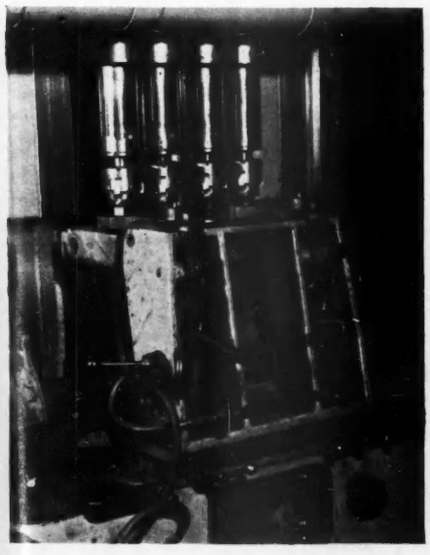

Fig. 4 Two cam-lever clamps locked by pivot-mounted air cylinders securing cylinder blocks on a vertical boring machine.

Each of the air cylinders employed in this system are double-acting and have been so chosen since they are required to apply a power stroke in both directions and spring-controlled return strokes are insufficiently reliable in automatic systems.

PNEUMATIC FIXTURES FOR OTHER MACHINE TOOLS

Examples of other forms of pneumatic clamping equipment are shown in Figs. 4 and 5. In Fig. 4 can be seen a fixture incorporating two cam-lever clamps, which are locked by trunnion-mounted air cylinders. It is used on a vertical boring machine, which performs the semi-finishing of cylinder bores. Also used at the factory is a pneumatic fixture designed for a vertical milling machine. It has wedge-lock vice-type clamps, operated by neck-mounted air cylinders and incorporates a lifting platform which is also pneumatic.

The two-station fixture shown in Fig. 5 has integral lifting platforms to permit loading at roller-conveyor height. Two hand-control valves are provided, one for the lifting platforms and the other for the clamps, which are applied in sequence, the centre ones first. The fine boring, chamfering and facing of crankshaft rear-end covers is performed on a machine which employs another fixture embodying direct-acting air cylinders.

AIR TABLE FOR LOCATING LARGE WORKPIECES

In addition to its use in clamping fixtures, pneumatic equipment has other machine tool applications, one of which is the sensitive air table. This consists simply of one machined plate resting on a second which has a grooved surface. The operation of a foot-valve introduces compressed air into the grooves, which causes the upper plate to float. The upper plate can then be moved by a negligible effort and the workpiece easily located.

The air table is of special value in setting large components in position on a drilling machine. The location of the component can be adjusted until the pilot enters the guide hole; the air pressure is then released and the machining operation can be completed.

CAPACITORS FOR OILFIELDS

Claimed to be the first of their type made in the United Kingdom, four high-voltage static-capacitor banks have been constructed by the Dubilier Condenser Company (1925), Limited, Victoria-road, North Acton, London, W.3, for use in the Venezuelan oil-fields of the Shell Petroleum Company. They are to be used on the transmission lines.

Each bank unit is enclosed in a sectionalised steel housing for mounting on a plinth outside existing substations. Each is complete with automatic control and switchgear and protective equipment. The separate capacitors are rated at 20 kVAr and at 4,000 volts, 60 cycles. They are arranged in three groups and star connected to the 6·9 kV supply. The standard Dubilier oil-impregnated paper-dielectric type has been used. Two of the banks have a total capacity of 600 kVAr and the other two are 1,320 and 1,380 kVAr. These can be increased by the addition of standard sections up to 720 kVAr for the first pair and 1,440 kVAr for the second. Any one capacitor unit can be withdrawn or inserted without disturbing the others. Owing to the severe climatic conditions, special precautions have had to be taken with regard to corrosion and humidity. Protection has also been made against attack by insects.

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MECHANISED HORTICULTURAL IMPLEMENTS

Power-Driven Attachments

Two new mechanised cultivators suitable for gardens, nurseries and smallholdings have been introduced by Rotary Hoes, Limited, Hornden, Essex. Both models are hand controlled, the operator walking behind the machines which are driven by single-cylinder four-stroke petrol engines. The larger model, the "Yeoman," is fitted with a 4·2-h.p. Villiers engine, the smaller, the "Bulldog," with a 1·2-h.p. J.A.P.; both are started by pulley and lanyard.

The "Bulldog" is a digging and hoeing machine with a direct worm-gear drive to the rotor and a V-belt drive from the worm shaft to the driven road wheels. The rotor tool is of the company's patented "Rotavator" type using L-shaped blades. A similar but larger tool is also the standard attachment for the "Yeoman," but on this model the drive is transmitted through a quick-release power take-off allowing rapid replacement by alternative attachments, including grass-cutters, hedge trimmer, electric generator, furrower or sprayer.

These two models bring the number of new machines marketed by the company since the beginning of this year to four. The previous machines were the single-pass soil-stabilisation equipment described on page 54 of our issue of January 8, and the "Platypus Bogmaster," described on page 285, February 26.

Fig. 5 Hand-operated valves control both the clamping action and the movement of the lifting platforms in the fixture illustrated here.

TRANSONIC AND LOW-SPEED WIND TUNNELS

DE HAVILLAND TESTS OF ENGINES, AIRCRAFT AND PROPELLERS

Two new wind tunnels have recently been completed for the de Havilland Aircraft Company, Limited, Hatfield, Hertfordshire – a high-speed tunnel capable of operating at Mach numbers ranging from 0·8 to 1·6, with a working section approximately 2-ft. square, and a low-speed tunnel for speeds up to 250 ft. per second, capable of accommodating models of 6 ft. wing span. The wind tunnels, which are to serve the whole de Havilland Enterprise, i.e., the engine and propeller companies as well as the aircraft company, are self-contained, with their own technical and drawing offices, well-equipped model shop and instrument room housed in the same building as the low-speed tunnel. Hitherto, all wind tunnel tests on de Havilland designs have been carried out by the Royal Aircraft Establishment and the National Physical Laboratory.

HIGH-SPEED TUNNEL

In deciding on the design of the high-speed tunnel, which is of the injector type, one of the principal considerations was to get it into full operation at the earliest possible moment. (Both tunnels, have, in fact, been designed and constructed in less than two years – an achievement which, the de Havilland company state, could not have been carried out without the wholehearted co-operation of the various contracting firms.) For this reason, and also to reduce the capital cost, three Ghost jet engines provide power for the tunnel. Although the running costs of such a tunnel are higher than those of an electrically-driven plant, the initial costs are considerably lower; there may also be some advantage in being independent of the grid system for tunnel power.

The layout of the high-speed tunnel is illustrated in Fig. 1. In brief, the exhaust from the three Ghost engines induces a flow of air through suitable ducting connected to an atmospheric intake; part of this ducting forms the tunnel working section. A proportion of the hot exhaust gases is bled back to the ducting on the upstream side of the working section to ensure that there is no condensation in the working section. The remainder of the hot gases is exhausted to atmosphere.

The design of the high-speed tunnel was initiated in June, 1952. To determine the best form of nozzle, tests were carried out in November, 1952, in the gas dynamics laboratory of the de Havilland Engine Company, Limited, on an ⅛-scale model of the injector section and final diffuser of the tunnel. Compressed air was passed through a combustion chamber taken from a Ghost engine to simulate the engine temperature and pressure conditions. Five sets of nozzles were tested, with a wide range of injector area ratio, and the effects of lengthening or shortening the nozzle, different nozzle tapers, etc., were investigated for various mass-flow and pressure-ratio conditions. From these tests it was concluded that an injector area ratio of 0·6 was the best compromise to give a high Mach number and a reasonable size of working section at lower speeds.

TUNNEL DUCTING

Also in November, 1952, an order was placed with G. A. Harvey and Company (London), Limited, Greenwich, for the manufacture of the high-speed tunnel structure except for the working section. This main structure, of pre-fabricated electrically-welded sections, is in general in mild steel to B.S.13 and 14; but for the hot section, which has to withstand temperatures up to 500 deg. C., a high-silicon boiler steel to B.S.1501-154, as used in oil-refinery pressure vessels, is employed. The plate thicknesses range from $\frac{3}{16}$ in. for the cross duct (Fig. 1) to $\frac{1}{16}$ in. and $\frac{3}{8}$ in. for the cooler and lightly-pressurised sections and $\frac{1}{2}$ in. for the hotter and highly-loaded sections. Some of the ducting being square or rectangular in cross section, required panel stiffeners for strengthening and for avoiding drumming caused by the jets at high speed Wherever practicable, the stiffeners in the hot section were made of uniform thickness to the ductwork shell, with the maximum area in contact with, and in close proximity to, the shell, in order to avoid relatively cold areas giving unequal expansion.

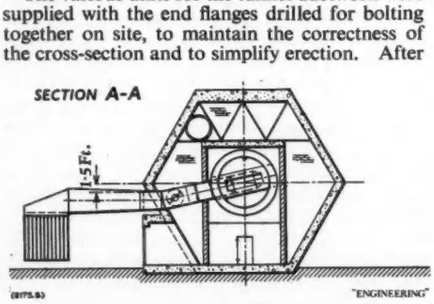
The various units for the tunnel ductwork were supplied with the end flanges drilled for bolting together on site, to maintain the correctness of the cross-section and to simplify erection. After bolting up, the flanged joints were seal-welded internally. To satisfy the exacting aerodynamic requirements, all internal welds were smooth-ground and faired off as necessary.

Fig. 2 The three Ghost engines which power the high-speed tunnel are arranged to give convenient access for servicing and replacement.

The contract for the detail design and manufacture of the working section, described in a subsequent paragraph, was placed with Foster, Yates and Thom, Limited, Blackburn, in January, 1953. It was delivered on November 23, and a fortnight later erection was complete.

ACOUSTIC TREATMENT OF ENGINE TUNNEL

The engines and exhaust side of the tunne are housed in an existing concrete building, formerly a propeller test bed, of hexagonal cross-section. The engine intake air enters through part of the original silencing installation of the test bed. To provide adequate exhaust silencing, special treatment has been necessary on account of the high temperature of the gases. For this reason, a heat-resistant structure of brick and fireclay has been erected within the original building, into which the exhaust is directed by three deflector vanes. A heat-resistant " island " diverts the flow through 45 deg. into two streams which re-unite to emerge into the outside



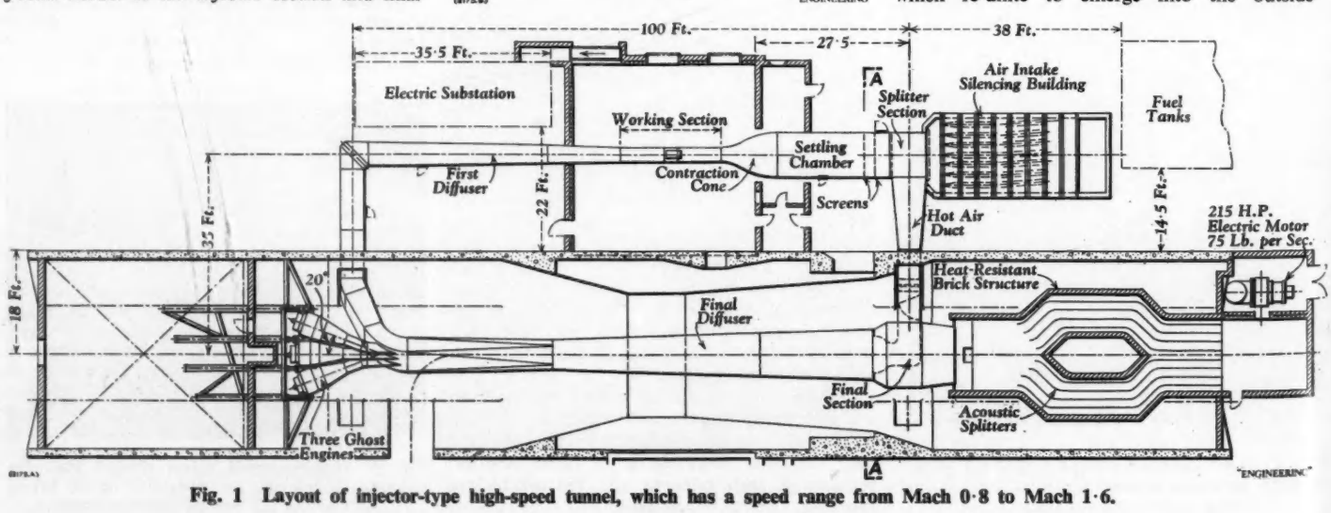


Fig. 1 Layout of injector-type high-speed tunnel, which has a speed range from Mach 0·8 to Mach 1·6.

Fig. 3 Looking downstream through the fixed contraction cone into the working section.

atmosphere. On each side of the island, and parallel with it, are four rows of sound-absorbent splitter panels, designed and constructed by Cementation (Muffelite), Limited, 39 Victoria-street, London, S.W.1. Each panel is 3 ft. long by 18 ft. high and is 3 in. thick. The 45-deg. bends contribute largely to the suppression of the higher frequencies. On account of the high temperature, the perforated steel sheeting of the splitters, which encases sound-absorbing material, is of somewhat heavier gauge than is normally employed in engine-silencing installations, and a special heat-resisting paint is used. The resulting noise outside the tunnel building, in the immediate vicinity of the exhaust, is practically confined to the lower frequencies.

COOLING AND EXPANSION

Above the heat-resistant exhaust structure is an acoustic splitter panel through which a cooling-air stream is drawn at 75 lb. per second by a 215-h.p. electrically-driven fan; by this means the engine building is maintained reasonably cool. When the engines run at maximum continuous speed, provision has to be made for some 6-in. expansion of the exhaust diffuser duct; the latter, which is anchored at the jet-inlet end, therefore incorporates a sliding-gland packed joint at the end of the final diffuser, and it is supported on swinging links and rollers which accommodate longitudinal movement.

The engines are controlled from the main control desk in the working-section building, but an override fuel-cut-off switch is provided for emergency use by the engine observer, who is stationed in a "sentry box" behind the inner forward wall of the engine tunnel building, looking on to the engines. The sole purpose of the engine observer is to keep a look-out for fire, and if it should occur, to cut off the fuel supply and operate the fire-extinguishing system which floods the engine installation with carbon dioxide. Operation of the emergency fuel cut-off switch also actuates a warning light on the main control desk. It should be mentioned that fuel is fed to the engines from an 800-gallon header tank which in turn is supplied by three continuously-running pumps from two 5,000-gallon underground tanks.

The three engines, it will be observed from Figs. 1 and 2, are arranged fanwise to allow easy accessibility for dismantling any one unit. To facilitate servicing and engine changes, a permanent servicing gantry and an overhead hoist are provided.

The airstream induced in the working section enters through an intake silencing building (Fig. 1) which houses acoustic splitters to prevent the noise travelling back from the engines when the tunnel is running at subsonic speeds. After leaving the silencing building the air enters the splitter section where it mixes with re-circulated hot gases from the exhausts (Fig. 5). It then passes through two stainless-steel screens, the first one acting as a filter to catch the larger impurities, the second to reduce turbulence.

The filtered air passes through a settling chamber 15 ft. long, before going into the contraction cone, which has an overall area ratio of about 15 to 1 for Mach 0·8 to 1·4, and 20 to 1 for Mach 1·6. Leaving the fixed contraction (Fig. 3), the air passes to the working section, which consists of three parts: the first, where the flow is generated, includes the model position; the central part houses the sting support-strut and incidence adjusting gear for the model; and the rear part forms the transition to the first diffuser. The whole working section is of robust construction to withstand the high inward loads without deflection; it is designed for a pressure differential of 12 lb. per sq. in. Fig. 4 shows the working section, before installation, with the side panels removed and Fig. 6 shows the final installation, again with one of the side panels removed.

ADJUSTABLE ROOF AND CEILING LINERS

The four removable vertical sidewalls are bolted with swing bolts to the top and bottom beams to allow for easy removal. They are 8 ft. long and 4 ft. high, and are of 1½ in. plate, stiffened with T-section ribs, planed and surface-ground and finished with a coat of heat-resisting Araldite. The four side-joint faces have machined grooves to take inflatable Dunlop rubber pressure seals. The width of the working section is 2 ft., but provision has been made for increasing the width to 2 ft. 6 in. if required.

Two of the sidewalls have windows of optical glass, 20 in. in diameter, in line with the model position. The formation and position of shock waves can be observed and recorded through these windows using schlieren apparatus.

The ceiling and floor are formed by shaped aluminium liners (Fig. 4) which fit flush with the fixed contraction upstream (Fig. 3) and are each supported by two screw jacks which permit the liners to be set at any desired angle to provide the required air velocity. This form of construction is unusual; most supersonic tunnels have fixed liner positions and a few have flexible nozzles. The de Havilland company have preferred to adopt a simple mechanical arrangement which permits easy and precise correction of the boundary-layer thickening along the working section. At supersonic speed it also allows tests to be carried out at a small range of Mach numbers on either side of the design value. Three sets of liners for the forward and rear parts of the working section are provided to cover the range from Mach 0·8 to Mach 1·6.

A high standard of machining was essential on the liner faces. The contour planing of the front, centre and rear ceiling and floor liners was carried out on a 7-ft. Butler planing machine, using special contour bars. After machining, the wind-swept faces were hand-scraped to give the necessary finish and were then sprayed with Araldite to withstand the elevated temperature in the section. Felt rubbing strips let into each side of the liners form air seals and also serve to protect the sidewalls when the liners are moved.

MECHANISM FOR ROTATING MODEL

The model is attached at the rear to a sting pivoted on a vertical strut which can be moved up and down through the centre tower of the working section. An ingenious mechanism has been developed so that the model can be rotated about its stationary centre of gravity by a combination of an angular displacement of the model sting and a vertical displacement of the main support strut, the two screw jacks providing these movements being geared together and driven by the same electric motor.

The main centre tower, through which the sting support-strut passes, is built up from 2-in., 1½-in., and 1-in. thick plate, with two side doors supported on hinges fitted with ball thrust races.

The inside faces of the centre section had to be machined parallel and ground to a tolerance of ± 0·0005 in. The front and back faces are cut to allow the lifting gear for holding the top liners in place to be fitted; in doing this, provision had to be made for sealing the slots to prevent any leaks from the outside atmosphere entering the tunnel.

The top and bottom beams of the working section are of welded box section, built up from 2¼-in. and 1-in. thick plate. The joints were machined to an accuracy of ± 0·0005 in. The main lifting screws which carry the roof and floor liners pass through slots in these beams; to seal the screws, cast-iron spherical block nuts, hand-scraped to 0·0005 in., were fitted in machined and ground plates. The blocks are fitted with brackets which carry the gear for operating the liner screws. The beams are

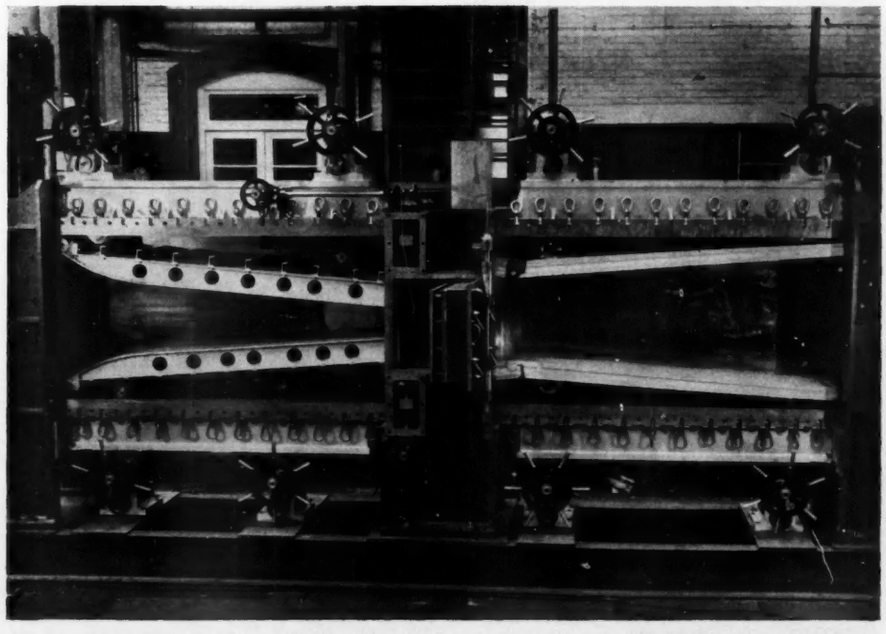


Fig. 4 The working section, with the side panels removed, before installation at the de Havilland works. The setting of the aluminium ceiling and floor liners can be adjusted by screw jacks to give the required tunnel speed. The centre tower accommodates the model-support and incidence-changing gear.

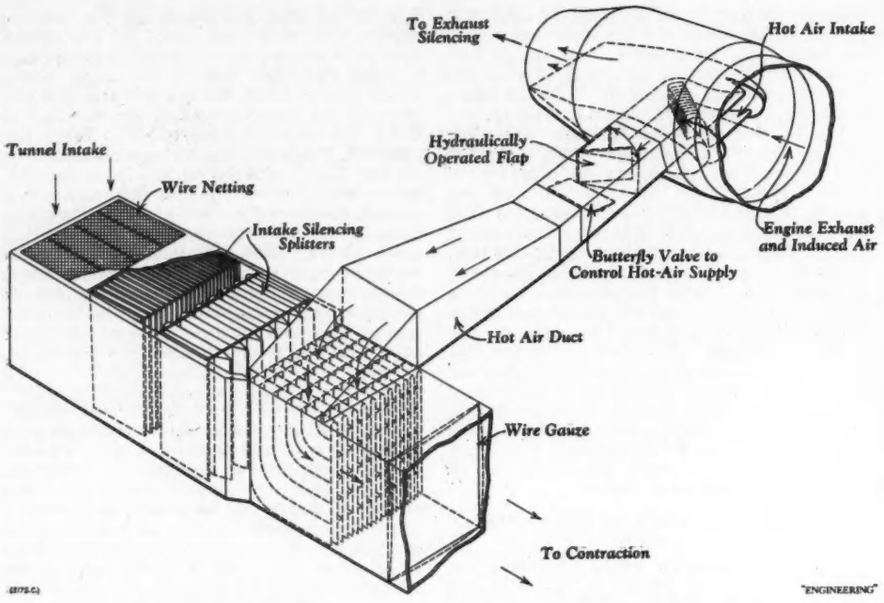


Fig. 5 Arrangement of the recirculating duct, which provides for ducting up to 15 per cent. of the hot exhaust gases through the working section to avoid condensation.

bolted to the centre tower and are supported at each end by two end towers.

The air, after leaving the working section, passes through the first diffuser which has an area expansion ratio of 3·5 to 1, giving an equivalent cone angle of 3·5 deg. It is turned through 90 deg. by guide vanes, and then flows upwards into the engine-tunnel building towards the engines, the section being reduced to the required area at the jet nozzles. Expansion joints are provided in the tunnel ducting before and after the guide vanes.

The airstream from the working section is mixed with the exhaust from the engines in a constant-area duct sufficiently long to provide efficient mixing. From here the mixture enters the final diffuser, of 4-to-1 area ratio and 4- to 5-deg. cone angle, before the final duct.

Across the final section is a large aerofoil with a leading-edge intake (Fig. 5) in which up to 15 per cent. of the hot gas is collected, turned through 90 deg. by cascades, and ducted into the splitters where it mixes with the incoming cold air. The amount of hot gas diverted to the working section is controlled, from the main control desk, by a butterfly valve in the hot air duct. The latter is also fitted with a hydraulically-operated bypass flap which is set to close the duct when starting up, in order to avoid circulating dirt and foreign matter through the working section. The flap is opened after the engines have run up to idling speed and it is desired to re-circulate hot air.

CONTROL AND MEASUREMENT

The tunnel power is controlled from the main control desk adjacent to the working section (Fig. 6). This desk incorporates an engine-control pedestal similar to those fitted on the Comet air liner, from which the engines – which are in fact those of the prototype Comet – are controlled through cables. An engine-starting panel similar to that on the Comet is also included in the control desk; a rectifier in the forward part of the engine-tunnel building provides the necessary direct current for starting. Also grouped on the control desk are the fuel supply controls and gauges, the hot-air butterfly valve, the engine tachometers, oil pressure gauges and jet-pipe temperature gauges, the working-section temperature gauge, the Mach-number gauge, and the incidence-recording dial.

All the loads on the model are to be measured by strain gauges. The de Havilland instrument laboratory have developed a six-component strain-gauge balance to fit completely inside the model. This balance, which incorporates 18 Baldwin Bakelite strain gauges, imported from the United States, is now undergoing calibration. The strain-gauge signals are indicated on Elliott self-balancing units.

LOW-SPEED WIND TUNNEL

The design of the closed-circuit low-speed tunnel is based on that of the 9-ft. by 7-ft. " industry tunnel " recommended by a committee of the Society of British Aircraft Constructors set up after the second World War, but incorporates a number of modifications. It is powered by an electrically-driven fan and is capable of speeds up to 250 ft. per second.

As in the high-speed tunnel, the main structure was supplied by G. A. Harvey and Company (London), Limited, but in this case it was constructed on site. Except for those sections of the tunnel which can be dismantled for access to working parts, the structure is of welded ⅜-in. steel plate throughout to minimise noise and vibration.

The working section is of 1-in. thick plywood, supported by stiffeners, supplied by Flexo Plywood Industries Limited, Flexo Works, South Chingford, E.4, Essex ; it is 18·5 ft. long, with a width of 8·7 ft. and a height of 6·7 ft. with corner fillets. Breather slots at the downstream end maintain atmospheric pressure in the working section.

Two large windows give a full view of the model during the test. One of these windows is incorporated in a large door which can be removed for installing the model; the working section is adjacent to the model room in which the models are constructed, and an overhead travelling hoist facilitates the transfer of large models, which usually weigh about 400 lb. and occasionally may weigh up to 800 lb.

Leaving the working section, the airstream passes into the first diffuser section, which has an equivalent cone angle of 3·3 deg., before the first 90-deg. cascade. The vanes of the cascade are of ¼-in. steel plate. A short section leads to the second corner cascade, through which passes the shaft, supported in three bearings, which drives the fan immediately downstream of the corner, in a section which has been increased in size in order to keep constant the airstream area around the tapered fan fairing. In the plane of the fan a protective ring of balsa wood is provided to eliminate any possibility of rubbing between the fan-blade tips and the steel walls of the tunnel.

After the fan section is the main diffuser, 87 ft. long, of 4-to-1 area ratio (equivalent cone angle 4·4 deg.) leading to the third and fourth corner cascades, which are of thin galvanised steel sheets reinforced by horizontal slats.

Provision is made to fit two screens in the section downstream of the fourth corner, but at present only one screen is fitted. This 30-mesh 33 s.w.g. stainless-steel screen, 17 ft. high and 22 ft. wide, has been woven as a single unit.

After the screen, the air passes through a short settling chamber and then into the 5-to-1 contraction cone which speeds it up before entering the working section.

ELECTRONICALLY-CONTROLLED FAN MOTOR

The 12-ft. diameter four-blade fan was supplied by the Airscrew Company, Limited, Weybridge. All the heavy electrical equipment, supplied by the British Thomson-Houston Company, Limited, Rugby, is housed in a motor room adjacent to the tunnel, the fan inside the tunnel being directly coupled to the driving motor by a 28-ft. long shaft which projects through the wall of the tunnel into the motor room.

The fan-driving motor is a direct-current machine rated at 450 h.p. continuously, with a two-hour rating of 500 h.p., 460 volts, at 800 r.p.m. Speed variation over a 4-to-1 range is by Ward Leonard control; the selected speed is automatically maintained constant, within ±0·15 per cent., by an electronic control system. Alternatively, the fan-motor speed can be controlled manually from the engine-control desk, adjacent to the working section. In

Fig. 6 The high-speed tunnel working section and control desk, from which the Ghost engines are controlled. One of the side panels is removed to show the upstream liners.

emergency, the motor can be brought to rest from full speed in about five seconds by a dynamic braking system.

The motor is supplied from a three-unit motor-generator set consisting of a 604-h.p. three-phase 50-cycle slip-ring motor driving a 400-kW 460-volt direct-current generator, and a 3-kW 250-volt exciter.

Above the working section is a six-component virtual centre balance, shown in Fig. 7, designed and manufactured by Test Equipment Limited, Crawley, who also supplied the Betz manometer which measures the tunnel speed. The model is suspended inverted from the balance, which is carried on four built-up L-shaped box-section steel pillars filled with sand and embedded in 4 ft. of concrete.

The balance is designed for the following load ranges, all measured about the wind axes: lift, +1,650 lb. to − 100 lb.; drag, + 500 lb. to − 100 lb.; side force, +1,250 lb. to −400 lb.; yawing moment, + 600 lb. ft. to − 1,200 lb. ft.; rolling moment, ± 600 lb. ft.; pitching moment, + 300 lb. ft. to − 1,200 lb. ft. The corresponding sensitivities are: lift, 0·50 lb.; drag, 0·10 lb.; side force, 0·15 lb.; yawing moment, 0·25 lb. ft.; rolling moment, 0·25 lb. ft.; and pitching moment, 0·15 lb. ft.

The balance is the first of its type capable of measuring all six components simultaneously and independently. It comprises a pylon or earth structure carrying two optically-aligned frames suspended by vertical and inclined links. The upper frame measures forces and the lower measures moments. A turntable for yawing the model is mounted in the moments-frame. All pivot points throughout the balance are in the form of universal or cross-spring flexures thereby eliminating "stiction."

The loads are measured by six electrically-driven steelyards which, with their attendant dropweight systems, are remotely controlled from the control desk. The null position of the suspended system is indicated electrically on instruments capable of detecting frame movements of less than 0·001 in. Forces and moments acting on the model under test are indicated at the control desk via Selsyn systems in terms of revolutions of the lead screws driving the steelyards.

The model may be yawed through approximately 350 deg. and provision is made for changing the angle of incidence of the model from + 40 deg. to − 20 deg. The model is supported from the balance by steel struts suitably shrouded by guards of aerofoil section mounted on the tunnel-roof turntable. These are kept pointing into wind when the model is yawed by an automatic mechanism.

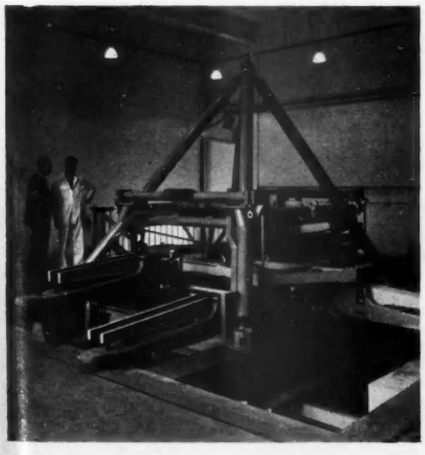
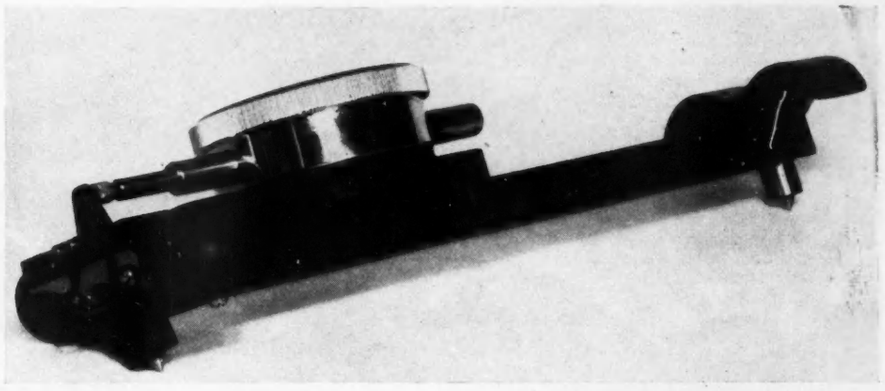


Fig. 7 The six-component virtual-centre balance of the low-speed tunnel, mounted above the working section. The loads on the model are balanced by electrically-driven steelyards controlled from a desk adjacent to the working section. Lift, drag, side force, pitching moment, rolling moment, and yawing moment can all be measured simultaneously.



The "Demec" strain gauge, which is used for rapidly taking a series of strain observations on structures. It has been developed particularly for use on concrete structures, when the readings obtained are accurate to within the equivalent of a stress of 12 lb. per square inch.

MECHANICAL STRAIN GAUGE

DEMOUNTABLE FOR RAPIDLY TAKING READINGS ON STRUCTURES

The accompanying illustration shows an inexpensive de-mountable mechanical strain gauge, the "Demec," which has been developed for rapidly taking, in succession and with reasonable accuracy, strain measurements at a large number of locations on a concrete structure. The standard instrument has a gauge length of 8 in. and is used to measure the relative movement of steel discs glued to the surface of the concrete by "Durofix." Development of the gauge, which is intended for use both in the laboratory and at site, has been done at the Wexham Springs research station of the Cement and Concrete Association, Framewood-road, Stoke Poges, Buckinghamshire. The prototypes were made at the research station but the gauges are now being made by Mayton Prototypes, 5 Mackenzie-street, Slough.

The gauge points glued to the concrete are formed from pairs of mild-steel or stainless-steel discs of $\frac{1}{4}$ in. diameter punched from $\frac{1}{16}$-in. sheet and drilled to about two-thirds of their thickness with a No. 60 drill (0·040 in. dia.). Hardened-steel points fitted to the instrument are located in the holes in the discs, and the first application of the gauge, or of the setting-out bar used to place the discs during gluing, slightly deforms the top of the hole to form an annular seating for the points. These seatings are sufficient to allow angular movement of the movable point about a sensibly fixed centre.

The movable point is carried on an arm pivoting about a knife edge which works in a seating formed by two parts, one a block with a flat hardened face and the other a plate, with one straight hardened edge, bolted to the face of the block to provide an accurate 90-deg. seating. The lengths of the two parts of the pivoted arm on each side of the knife edge are in the ratio of 8 to 10 so that the movement on the 8-in. gauge length is translated into a reading on the dial gauge which has only to be divided by 10 to compute the actual strain. A Mercer dial gauge with jewelled bearings is used to register the strain measurement.

The main beam of the instrument can be either of mild steel, in which case it is bolted to the dial gauge platform, or of Invar, when a grooved seating in the platform is required. This grooved seating with an Invar main beam is necessary because the dial platform is made of mild steel and must be allowed to slide along the main beam as it expands with an increase in temperature. Both the dial platform and the beam are fixed only to the block of the pivot seating. Any expansion of the dial platform itself is nearly equal to that of the plunger of the dial gauge, and overall thermal effects are thus very small.

With gauges having main beams of mild steel, however, and to a much lesser extent those of Invar, it is necessary to correct for thermal expansion of the instrument by checking periodically against an Invar dummy bar. This dummy bar, or master, also provides a standard for reference should the gauge be severely knocked or require to be dismantled for cleaning.

Insulated handles, so fixed as to ensure that the slight thrust applied by the operator causes no deformation of the instrument, complete the gauges. The illustration depicts a prototype with an Invar main beam.

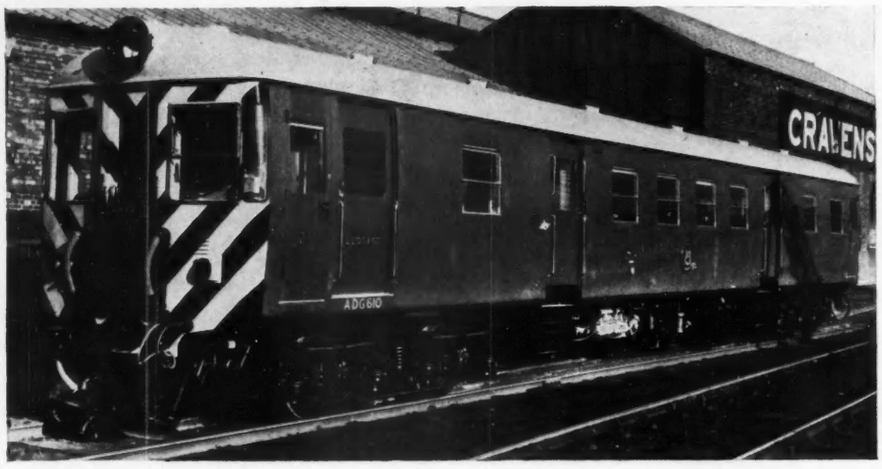
Development tests on the gauge showed that, under ideal conditions, strains could be read with 90 per cent. of the strain readings being within $\pm 3 \times 10^{-6}$ of the true figure, the limits of the discrepancy being equivalent to a stress of about ± 12 lb. per square inch in an average structural concrete. Under site conditions or in positions of difficult access, the accuracy of reading would be somewhat less, though a certain amount of practice by the operator will eliminate most sources of error. The rate of obtaining readings has been found to vary between 200 and 400 an hour according to the accessibility of the gauge lengths.

★ ★ ★

PRODUCTIVITY IN PRESSED-METAL INDUSTRY

In a "Review of Productivity in the Pressed Metal Industry," a pamphlet issued, price 2*s*., by the British Productivity Council, 21 Tothill-street, London, S.W.1, it is emphasised that greater attention should be paid to standardisation and simplification, although it is recognised that in many instances it is the producer of the finished article and not the producer of pressed metals who decides policy on this matter.

Among other subjects dealt with in the review are plant layout, safety measures, new techniques, labour conditions and materials handling, a feature which has been extensively modernised by members of the industry. The pamphlet also contains details of the individual efforts made by 13 different firms to increase their productivity.



One of the 18 railcars for suburban services at Perth, Australia. Two 125-b.h.p. engines are fitted under the floor. At each end there are inter-communicating doors, A.B.C. couplers and cowcatchers.

DIESEL-MECHANICAL RAILCARS

CONTROLS FOR SINGLE OR MULTIPLE OPERATION

The first of 22 Diesel-mechanical railcars for the Western Australian Government Railways was completed recently by Cravens, Limited, Sheffield, 9, who until recently were known as Cravens Railway Carriage and Wagon Company, Limited. The cars are designed to work singly or in multiple units up to a maximum of four and the wiring is so arranged that they can be coupled together in any order and driven from either end. Driving power is obtained from two A.E.C. 125-b.h.p. Diesel engines fitted below the floor of each car.

Eighteen of these vehicles will carry passenger traffic over 3 ft. 6 in. gauge track in the Perth district. They hold 110 passengers, 48 standing and 62 seated, and at one end there is a luggage compartment of 1-ton capacity. The other four will work up-country traffic. Each of these cars will have 16 seats in two compartments, two toilets, cold-storage space and a 23-ft. long freight compartment of 5-tons capacity.

Both types of car are similar in appearance, but the freight type are fitted with double sliding-doors at each end in place of the single passenger-entry doors which can be seen in the illustration above. A door and gangway at each end provide access between cars of a multiple unit.

The leading dimensions and performance figures of the vehicle are as follow:—

Length over headstocks	62 ft. 6 in.
Overall width	9 ft. 0 in.
Overall height	11 ft. 8 in.
Bogie centres	44 ft. 0 in.
Bogie wheelbase	7 ft. 0 in.
Dia. of wheels	2 ft. 7½ in.
Tare weight	29 tons 13 cwt.
Passengers and luggage	8 tons 0 cwt.
Bogie weight	5 tons 1 cwt.
Acceleration on level track	0—10 m.p.h. in 6·75 sec. 0—20 m.p.h. in 20·75 sec. 0—30 m.p.h. in 44 sec.
Braking	40 m.p.h. to rest in 21 secs. (216 yards). 2 m.p.h. per sec.
Tractive effort	7,600 lb. at wheel.
Maximum governed speed	50 m.p.h.
Fuel consumption	5 miles per gall.
Lubrication oil consumption	350 miles per gall.
Range without refuelling	450 miles.

The underside view reproduced on this page shows the two engines in position. The drive from each engine is taken through a fluid flywheel, freewheel and four-speed Wilson epicyclic-gearbox to the inner axles of one bogie. Bevel crown and spur pinions provide the final drive to the axle. Forward and reverse drive is engaged by an air-operated dog clutch.

The radiators for the engine-cooling water can also be seen in the picture, one on each side, with the fan-driving shaft projecting inwards from the rear of the suction fan. Header tanks are located beneath adjacent passenger seats. Should the cooling water fall below a pre-determined level a relay-trip switch is energised and the engine is stopped. The lubricating oil from the engine is warmed when starting by passing through a Serck heat-exchanger which is connected with the engine-cooling water system. The circuit is thermostatically controlled and after the oil has reached a certain temperature cooling can be effected in a similar manner.

The body and underframe are of integral design, lightweight welded steel construction being used throughout. Tubular members have been used for the solebar and cross-bar sections. Two channels run longitudinally under the main cross-bars, in the centre of the underframe. These channels support the engines at three points and also carry the fuel tanks, batteries, radiator fan drive and generators. The underframe bolsters and end-frame assemblies are fabricated from flanged mild-steel plates to form box sections. The headstocks are of heavy box design and the body framing is built from ⅛-in. steel cold-formed pressings and longitudinal members of Corten low-alloy steel.

The side panels for the body are made from 16-s.w.g. steel sheet. The roof framing is covered with galvanised sheets of 16 s.w.g. strapped in position and held by button welding. A weather-proof joint is formed by continuous seam-welds along the butt joints. The side member of the underframe is made from ⅛-in. plate and welded flush with the body side-panel. In this way it forms a combined solebar and side skirting.

The seating in the suburban cars is arranged to give the maximum of standing area and strap hangers and crush barriers are provided. Reversible type seats upholstered in Vynide are fitted. The passenger-compartment lighting equipment has been made by J. Stone and Company (Deptford), Limited, London, S.E.14. The interior is painted tan colour from the cantrail to the top light rail, cream down to the waist rail and green below. The exterior is finished in larch green with a stone-coloured roof and body ends in black and yellow diagonal stripes.

Cow-catchers and A.B.C. centre couplers are fitted at each end. Sliding doors give access to the passenger compartment and hinged doors are fitted for entry to the driver's compartment. To facilitate entry from rail level folding steps have been fitted. These steps are controlled by an air motor and cast-iron balance weights, and are interlocked with the brake system.

A bolster type of bogie has been fitted having outside springs and swing links. The axle boxes house Timken roller bearings. The wheels and axles are to Western Australian Standards and were made by Owen and Dyson, Limited, Rotherham, Yorkshire. Fully-equalised bogie-brake equipment is used with standard two-piece brake-blocks

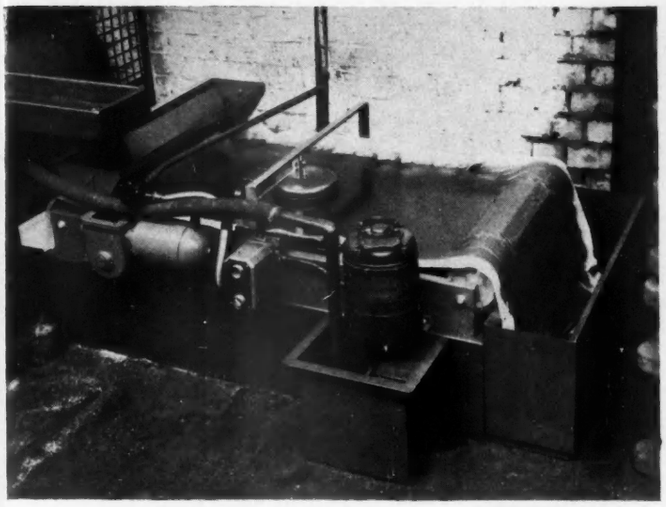
The quick-release type of vacuum-brake equipment specially designed for Diesel-mechanical units is fitted. The exhausters are connected to a separate exhauster pipe-line which is in communication with the normal brake train-pipe through the driver's brake valve and feed valve. A dead-man valve with a time lag device and the passenger communication-cord is incorporated in the brake equipment.

The driver is seated on the left-hand side of the car. Alongside the seat is the dead-man type control and grouped together on a desk in front are the driving controls and instruments. The normal controls are supplemented by eight engine-starting buttons, eight lights to indicate that each engine is running and correct oil pressure is being maintained and four lights to show that the air pressure in each car, when working in multiple, is above 40 lb. per square inch. The gear change control operates through a pre-selector system and an engine-speed indicator shows when to change from one gear to another.

A small switch panel is fitted for the conductor's use; this incorporates a bell push and a control for the folding steps. A Bostwick gate closes across the driving compartment to isolate the controls from passengers passing between cars.

Power for lighting and starting is drawn from 24-volt batteries of 384-ampere-hour capacity. These are charged by C.A.V. 8-in. compensated voltage-control type generators.

Looking-up beneath the centre of the chassis, the two engines, radiator fan drive and auxiliary drives are visible.



Shown fitted to a Lumsden grinder, this automatically-operated coolant clarifier filtered off 1·5 cwt. of swarf and sludge in 5 hours. The motor driving the coolant circulating pump is in the foreground (mounted vertically) and the one for advancing the filter material is on the left.

COOLANT CLEANSING

Removal of All Types of Solid Material

In wet grinding it is necessary to keep the coolant clean and free from swarf if a fine finish is to be obtained. It is obviously uneconomic to let the coolant run to waste after a single pass and therefore some form of filter, or sometimes a settling tank, is used. For this reason the Industrial division of Philips Electrical, Limited, Century House, Shaftesbury-avenue, London, W.C.2, have recently added a series of Universal clarifiers to their range of filtration equipment.

The new clarifier is designed to remove all contamination, including the fine suspended particles of swarf and grinding-wheel dust, from any type of coolant. It is entirely automatic in operation and the only attention required is that the sludge box be periodically emptied. The equipment can be fitted to all types of grinding machines. Ample coolant-storage capacity is provided, so that it is possible to dispense with normal settling tanks by fitting the machine coolant pump into the compartment provided on the clarifier. The illustration shows one fitted to a Lumsden grinder at the works of Alfred Herbert, Limited, Coventry. In five hours, 1½ cwt. of swarf and sludge were filtered out for the expenditure of a 9 ft. length of the filtering material.

The polluted coolant, leaving the workpiece, flows into a trough of special filtering material carried on an endless wire-mesh conveyor. The filtering medium retains all swarf and abrasive dust on its surface but is sufficiently porous to permit a free and uninterrupted flow of filtered coolant into the sump of the clarifier whence it is returned by pump to the grinding head. As the filtering medium becomes saturated the fluid level in the trough rises and lifts a float. At a pre-set height this float operates a micro-switch and an electric motor moves the wire-mesh conveyor forward to provide a clean filtering trough and to automatically deposit the contaminated filtering medium into an open sludge box. In the illustration, the cover has been removed to show the float and filtering trough.

There are four standard models of the clarifier being made having capacities of 500, 1,000, 1,800 and 3,000 gallons per hour, and a larger model is being designed which will accommodate a coolant flow of 4,800 gallons per hour. These approximate flow rates are for normal soluble-oil coolants and depend both on the stock removed and the viscosity of the coolant.

It is claimed that, by fitting the clarifier, the continuous supply of clean coolant has given an improved finish on the work; longer wheel life; more consistent control of work conditions; reduced maintenance cost; an extended useful life of coolant; and increased production due to less down time for wheel dressing and settling-tank cleaning.

The clarifier also promotes more hygienic working conditions and provides an easy means of collection for salvaging valuable scrap.

* * *

FLAMEPROOF SWITCHGEAR

New Range of Equipment for a Variety of Uses

A new range of flameproof switchgear has been developed by the General Electric Company, Limited, Kingsway, London, W.C.2, for use in collieries, oil refineries, chemical works, gas works, grain elevators, painting and spraying plants and similar situations. It can also be employed out-of-doors and for any application requiring exceptional robustness. The equipment can be used for building two- and three-phase four-wire flameproof medium-voltage distribution switch-fuse boards, which will take currents up to 100 amperes at 660 volts. The individual switch-fuse units may also be used alone. The new range includes double pole and triple pole (with neutral) switches, fuse and bus-bar chambers, terminal boxes, conduit adaptors, cable-sealing boxes and cable-box reverse-entry chambers, together with such accessories as support brackets and cover plates for blanking off the bus-bar chambers. The units are completely interchangeable.

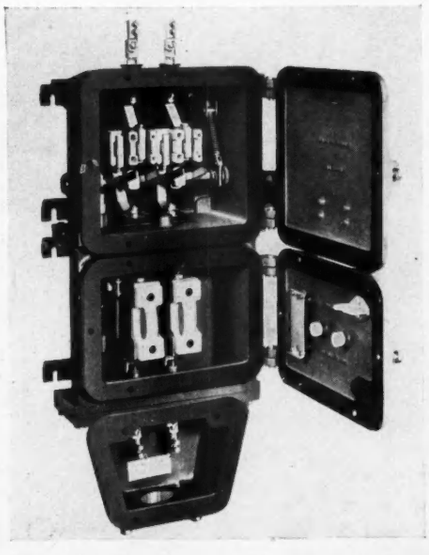


Fig. 1 A 30-ampere double-pole switch-fuse, with the switch located above the fuse chamber.

The equipment complies fully with British Standard Specification No. 229/1946 (flameproof enclosures of electrical apparatus) and with British Standard Specification No. 861 (air-break switches). All the units have also been tested by the Research Establishment of the Ministry of Fuel and Power at Buxton, and are certified flameproof for Groups 1, 2 and 3, as defined in British Standard Specification No. 229/1946. The fuse chambers are supplied with fuseholders either for rewirable fuses or for high-rupturing-capacity cartridge fuses, the latter being rated in accordance with category 550AC5 of British Standard Specification No. 88/1952 (electric fuses).

CONSTRUCTIONAL DETAILS

The switch-fuse unit, which is the basis of the new system, consists of a switch and a set of fuses, as shown in Fig. 1. In order to comply with British Standard Specification No. 229, these are accommodated in two flameproof chambers, each of which has a separate cover. A mechanical inter-lock prevents the fuse chamber cover from being opened unless the switch is open and prevents the switch from being closed unless the fuse chamber has previously been closed. The interlock mechanism is completely housed within the two chambers, so that it is fully protected from any damage or interference. Each switch-fuse unit is equipped with a terminal box, which is bolted to the fuse chamber and forms a third self-contained flameproof enclosure.

Two forms of switch-fuse unit are available: one has the fuses above and the other below the switch. Where a switch-fuse is used separately, and is not attached to a bus-bar chamber, a second terminal box has to be fixed to the open end of the chamber.

Double pole switch-fuse units are available for currents of 15, 30 and 60 amperes, and triple pole and neutral units for 15, 30, 60 and 100 amperes. Each unit consists of two heavy cast-iron cases which are permanently bolted together. Each switch and fuse chamber has four steel fixing lugs, so that it can be bolted to any flat surface. The connections through the walls of the cases are protected with flameproof gas-tight bushings of resin-impregnated paper.

Seven sizes of bus-bar chamber are available corresponding respectively to the seven current ratings and the number of poles of the switch-fuse units. Each chamber, of which an example is illustrated in Fig. 2, has four bus-bars, irrespective of the current rating of the corresponding switch, each of which is rated at 300 amperes.

Each bus-bar chamber has one closed and one open end. The bus-bars are taken through the closed end in flameproof bushings and each is provided with a connector so that, when several bus-bar chambers are bolted together end to end, the bus-bars can be coupled.

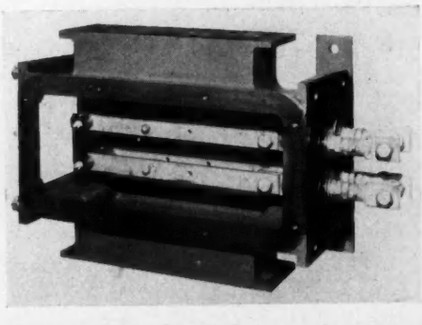


Fig. 2 Bus-bar chamber for medium-voltage flameproof switchgear.

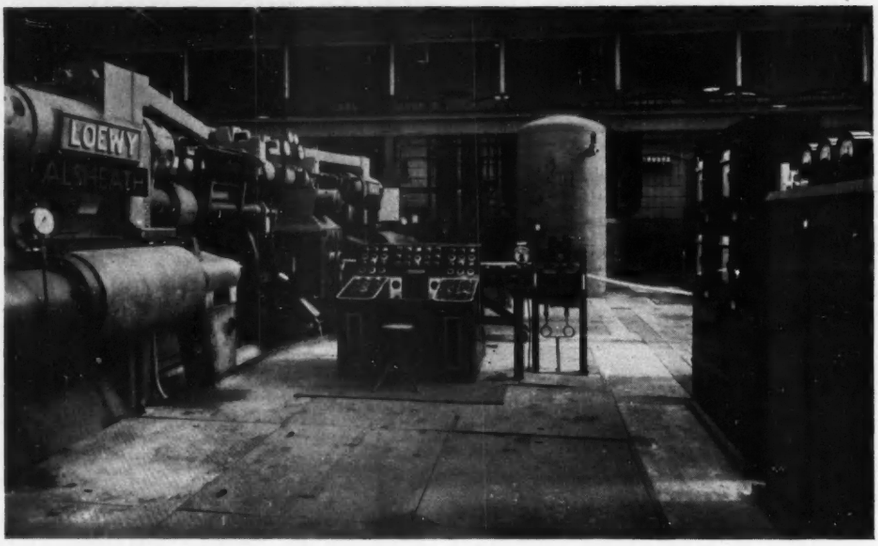


Fig. 1 Extrusion press for continuously sheathing cables with aluminium. Solid billets are pressed into the extrusion chamber by two horizontally-opposed hydraulic cylinders which together develop a force of 3,000 tons.

CONTINUOUS ALUMINIUM-EXTRUSION PRESS FOR CABLE SHEATHING

IMPORTANT ADVANCE IN CABLE MANUFACTURE

Great interest has been shown in recent years in the development of techniques for sheathing electric cables with aluminium instead of lead, largely because of the high cost and comparative scarcity of the latter metal. Considerable progress has been made and some thousands of miles of aluminium-sheathed cables are already in use. Hitherto, at least as far as this country is concerned, such cables have generally been produced by what is known as the "tube-sinking" process, in which the conductors and insulating material are first drawn into a long aluminium tube of suitable diameter, which is then reduced by drawing the tube with the conductors and insulating material in position through a die, thus closing the aluminium down into close contact with the insulation. Such cables have proved quite satisfactory, but suffer from the drawback that they cannot be made in continuous lengths as can lead-sheathed cables.

REQUIREMENTS OF THE PROCESS

One of the difficulties of sheathing cables by the extrusion process used in lead sheathing is that the temperature necessary for aluminium sheathing by extrusion is normally higher than is required for lead, so that there is some risk of impairing the properties of the insulation. British Insulated Callender's Cables, Limited, whose London office is at 21 Bloomsbury-street, W.C.1, have been studying the problem at their Prescot works for some years and have now overcome the initial difficulties, at least as far as low-voltage cables are concerned, so that they are able to produce aluminium-sheathed cables by the direct extrusion process in practically unlimited lengths. The development work is still proceeding but has now reached a stage at which the firm considered it desirable, because of its great technical interest and economic importance, to acquaint the electrical engineering industry with the progress made. They accordingly invited a party of electrical engineers and others to their Prescot works on Thursday, June 3, to see the process in operation.

After careful preliminary studies and experimental work the company reached the conclusion that in a normal production process of sheathing cables with aluminium by extrusion, it would be necessary to use commercial grades of aluminium in the form of solid billets; that extrusion temperatures should not exceed 300 deg. C.; that it must be possible to produce sheathed cables in long continuous lengths; that there must be satisfactory welds between successive billets; that the charging time must be kept as brief as possible to prevent overheating while the cable is stationary in the press; and that deformation and metallurgical defects at "stop marks," that is the point of the sheath which is in the die while the cable is stationary for re-charging, must be avoided.

PRINCIPAL FEATURES OF EXTRUSION PRESS

As no existing press covering all these requirements was available, the company co-operated with the Loewy Engineering Company, Limited, London, in designing a suitable press and the result of their combined efforts, known as the Alsheath press, is now installed in the Prescot works. It is shown on the left in Fig. 1, with the control desk in the centre of the illustration and the heater-control panels on the right; the sheathed cable leaving the press on its way to the take-up drum can be distinguished. The general arrangement of the plant is shown in the sketch plan, Fig. 2. It will be clear from this that the press comprises two horizontally-opposed hydraulic cylinders, each of which is 45 in. in diameter and is operated at a pressure of 4,280 lb. per square inch giving a force of about 3,000 tons. The cable, it will be noticed, passes through the

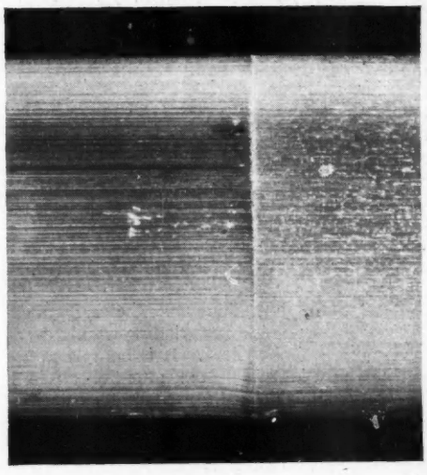


Fig. 3 "Stop mark" in an aluminium cable sheath.

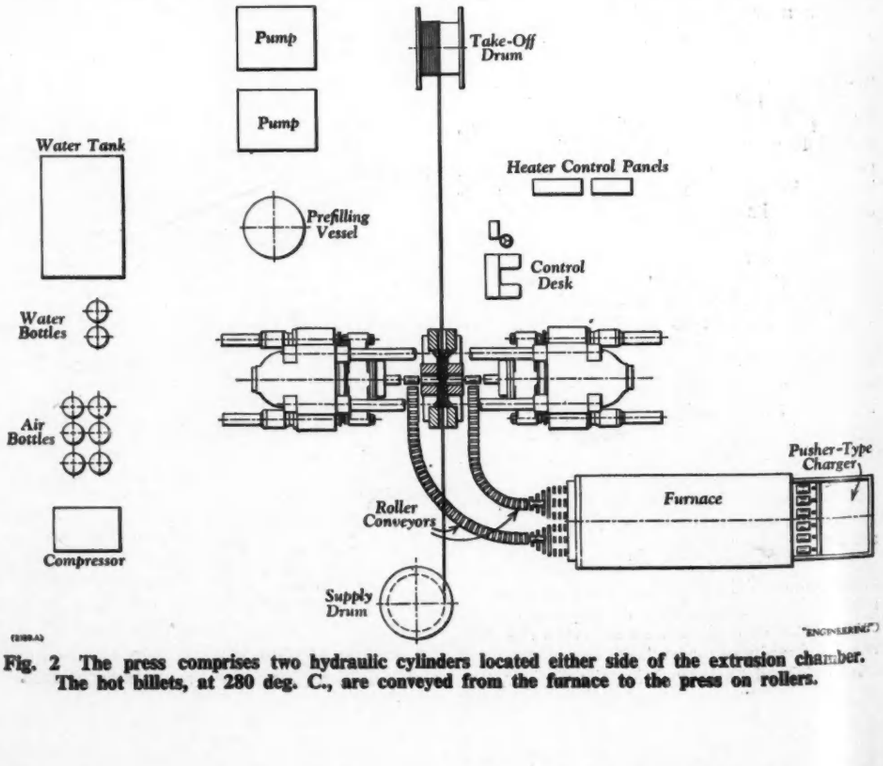


Fig. 2 The press comprises two hydraulic cylinders located either side of the extrusion chamber. The hot billets, at 280 deg. C., are conveyed from the furnace to the press on rollers.

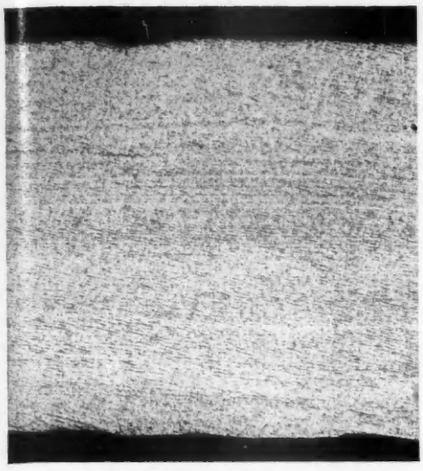


Fig. 4 Longitudinal micro-section through " stop-mark " in cable sheath. × 30.

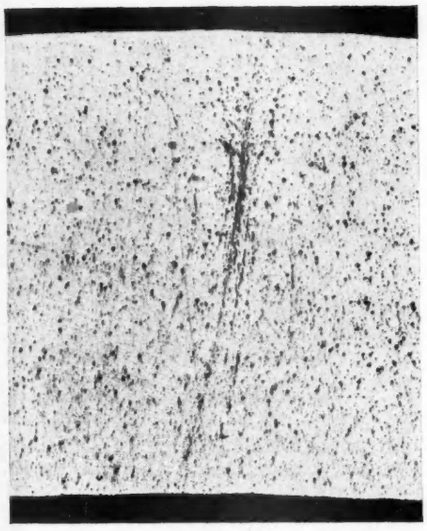


Fig. 5 Transverse micro-section through cable sheath showing seam features at top position. × 30.

press in a direction at right angles to the axis of the cylinders, which permits the use of solid billets and reduces to a minimum the length of cable exposed to the heat of the press. Twin billets are used and are extruded through a common core and die to form sheaths ranging from 1·4 in. to 3·5 in. in diameter.

The billets, which are cylindrical, are charged into an electrically-heated furnace six at a time, leaving from the other end of the furnace in pairs at a temperature of about 280 deg. C. They then run down roller conveyors to a point below the level of the extrusion chamber of the press, whence they are raised, in a cradle, and turned round at right angles so that they lie on the axis of the hydraulic cylinders. They are pushed simultaneously into opposite ends of the extrusion chamber, by the action of the rams, the continued slow motion of which forces the metal out through the dies in the form of a sheath surrounding the cable. The extrusion chamber is heated and is kept under a vacuum while extrusion is proceeding. It should be mentioned that the extrusion tools are mounted in such a way that their positions and the gap between them remain constant, irrespective of expansion or contraction due to temperature variations. Special controls ensure that the extrusion of the two billets is constantly balanced and the mechanical loading facilities provided enable a pair of billets to be re-charged in a few seconds. The major movements of the press are controlled by servo-operated valves from the desk and the control can be made fully-automatic or individual, as desired.

We understand that the initial objectives indicated above are being attained and that the press will shortly take its place as a routine tool in cable manufacture. Sufficient experience has now been obtained to show that the " stop-marks " are satisfactory from the dimensional and metallurgical aspects (see Figs. 3 and 4), and they have been found to comply with bend-test requirements and to withstand a high hoop stress. The welds formed between successive billets (as distinct from the " stop-marks ") cannot be discerned on the extruded sheath and the top and bottom welds, which are unavoidable in right-angle extrusion, resemble those formed in the conventional lead press (see Fig. 5). Aluminium of 99·8 per cent. purity is employed and with an extrusion temperature of 280 deg. C. the sheaths are in the lightly-annealed condition. The tensile strength is 5 to 6 tons per square inch, and the elongation is 30 to 50 per cent. on a length of 2 in., in the longitudinal direction of the sheath, depending on diameter and thickness. A fine grain is found in all parts of the sheath, including the " stop-marks," as shown in Fig. 4. With these properties it will be clear that the springiness associated with cold working is largely eliminated.

PRESENT POSITION OF PROCESS

Although the press has still to be equipped with the tools required for the production of a comprehensive range of cable sizes and the performance over that range has still to be proved, enough has now been done to show that a practical solution to the problem of sheathing cable with aluminium by a continuous-extrusion process has been reached and the two firms mainly concerned must be congratulated on the results.

On the occasion of the visit, a three-core paper-insulated cable for 600 volts, with a sheath $1\frac{5}{8}$ in. in diameter, was being produced at the rate of about 20 ft. per minute. Lengths of it were subjected to bending tests in comparison with similar lead-sheathed cables. The billets used were about 6 in. in diameter and 14 in. in length. The jointing of cables with aluminium sheaths and aluminium conductors was also demonstrated and those interested were able to see in progress the rolling of aluminium rod, wiredrawing, and the stranding of steel-cored aluminium conductors.

ELECTRICITY FROM ATOMIC POWER

Steam Generation System at Calder Hall

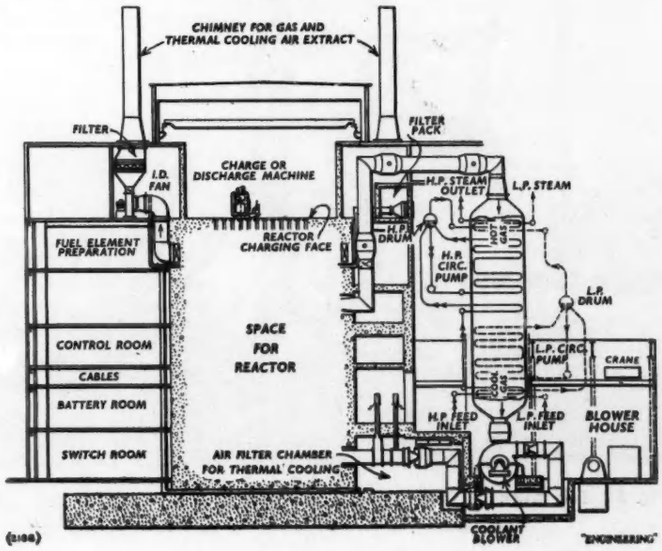
The atomic power station, which is now being erected at Calder Hall, Cumberland, to examine the technical problems and economics of this form of generation and to supply energy to the national grid, will consist of two graphite-moderated gas-cooled natural uranium reactors. These reactors will have an active core about 30 ft. in diameter, which will be contained in a pressure vessel of 40 ft. in diameter. They will each be associated with four steam-raising towers about 80 ft. high, a typical sectional elevation of which is given below.

The maximum surface temperature of the fuel in the reactors will be about 400 deg. C. and the heat generated in them will be conveyed to the steam plant by carbon dioxide at a pressure of about 100 lb. per sq. in. The hot gas will give up its heat to the pre-heating, evaporating and superheating sections of the plant and after passing through the steam-raising towers will be returned to the reactors by blowers and the cycle repeated. Use is made of a double-pressure steam cycle in order to obtain the maximum efficiency.

The complete towers and the associated feed pumps and other equipment are being constructed by Babcock and Wilcox, Limited, Farringdon-street, London, E.C.4. There will be separate sets of steam-raising equipment, including high-pressure and low-pressure economisers, evaporators and superheater sections and feed pumps. To obtain the maximum heat transfer within the towers all the heating surfaces will be of steel-tube construction to give an extended surface. There will be no joints inside the pressure shells, except those which, having been completed and tested in the shops, will not have to be broken during the anticipated life of the plant.

An interesting feature of the station will be that chimneys in the accepted sense will not be necessary as no coal or oil will be burned. Two comparatively small vent pipes will, however, be provided for extracting any heat from the reactors which is not transferred to the steam towers.

The turbines, which are being manufactured by C. A. Parsons & Company, Limited, Newcastle-on-Tyne, have been designed so that the low-pressure section can be supplied both with live steam and with steam that has been expanded in the high-pressure blading. The circulating gas blowers and pipe work are also being constructed by Parsons and the pressure vessels of the reactors by Whessoe, Limited, Darlington. The main contractors for the building are Taylor Woodrow Construction, Limited, Southall, Middlesex.



A typical sectional elevation of thermal reactor at Calder Hall power station. The station will have two natural uranium reactors which are to be graphite moderated and gas cooled.

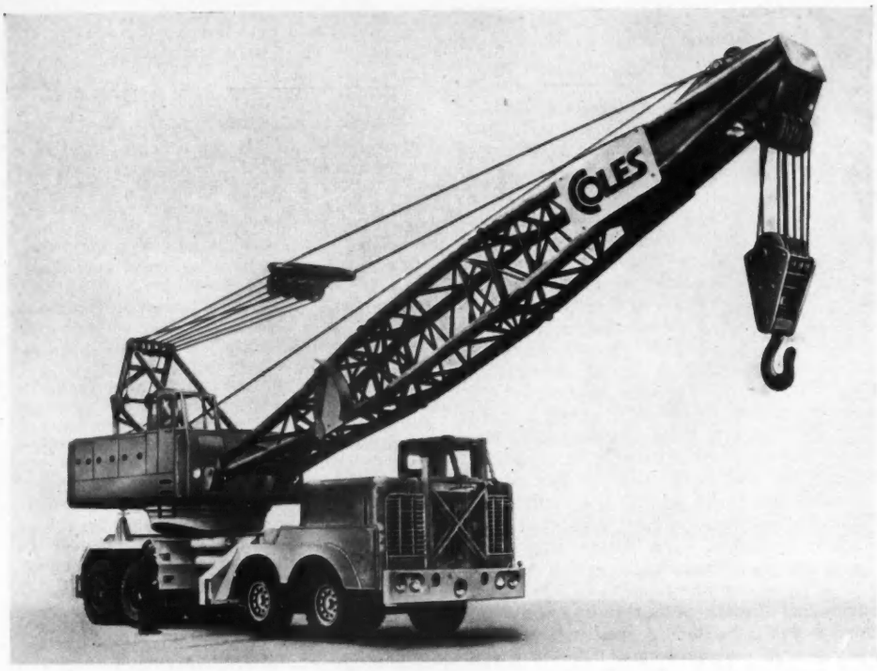


Fig. 1 The Coles "Colossus" is claimed to be the largest mobile crane in the world. When fitted with a 30-ft. jib it will lift 92,000 lb. at 12 ft. radius.

Fig. 3 Practically any bulk or packaged material can be moved by this natural-frequency conveyor. The rate of travel along the conveyor is about 70 ft. per minute.

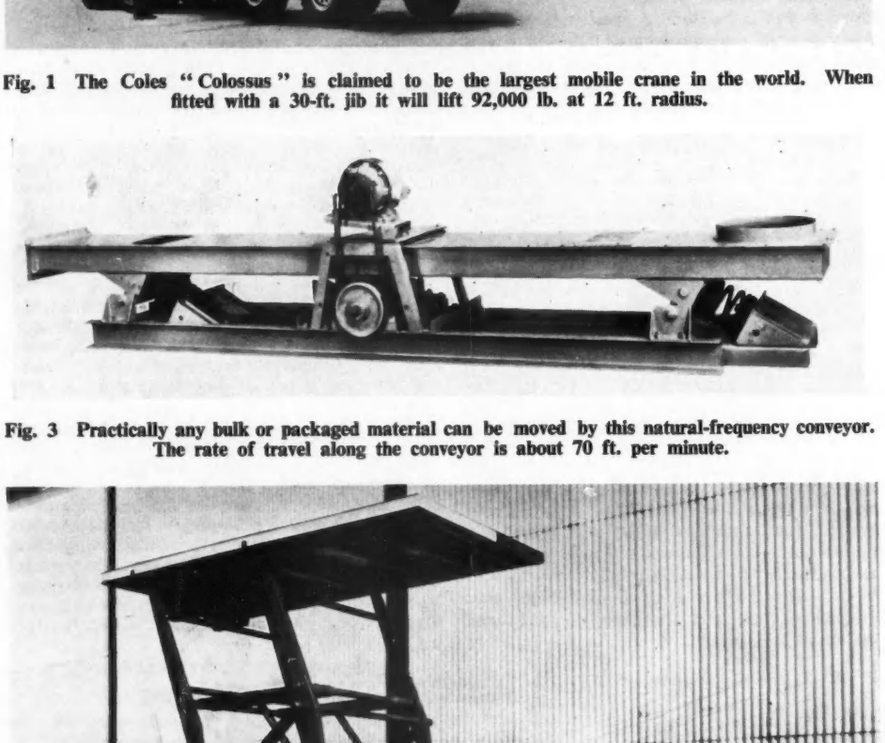


Fig. 5 This truck has been designed particularly for loading aircraft. The maximum platform height is 11 ft. 6 in. and it can raise 2,700 lb.

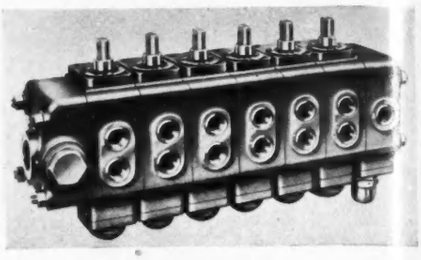


Fig. 2 A multiple-valve block for hydraulic power transmission, built from standard parts.

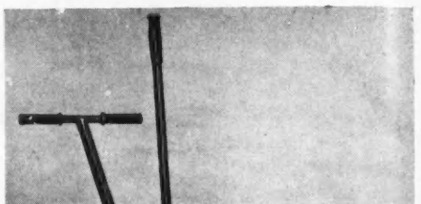


Fig. 4 This small manually-operated trolley, the "Minigrip" will lift and cart packages up to 2 ft. wide and weighing 2¼ cwt.

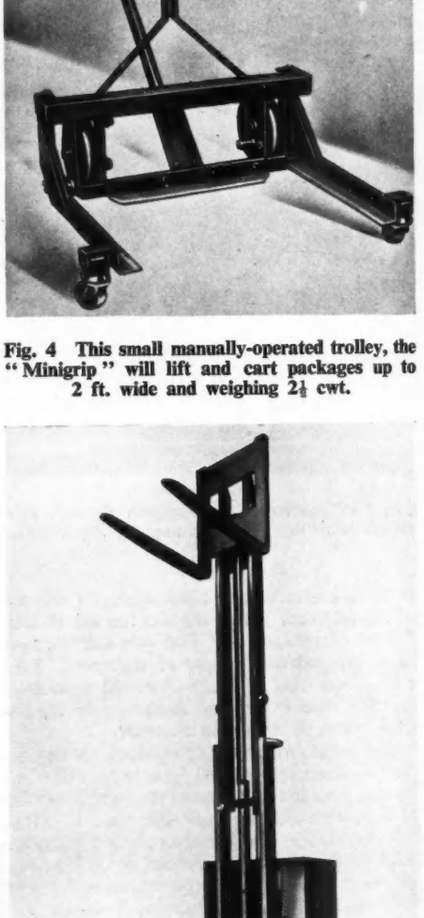


Fig. 6 The "Warehouser," a straddle-type fork-lift truck, will stack 48-in. square pallets from an aisle 6 ft. 4 in. wide.

MECHANICAL HANDLING EXHIBITION

CRANES, TRUCKS, CONVEYORS AND HYDRAULIC TRANSMISSION UNITS

The increasing awareness of industry in the part that mechanical handling can play in improving production efficiency and speeding the turn-round of ships and other means of transport is well illustrated by the variety of machines, many of which have not been displayed in public before, on show at the Fourth Mechanical Handling Exhibition now being held at Olympia. The exhibition, opened on June 9, by Mr. A. R. W. Low, M.P., Parliamentary Secretary to the Ministry of Supply, is held biennially and will remain open until June 19. About 200 exhibitors are taking part. A convention, at which eleven papers dealing with some of the differing fields of mechanical handling will be presented, is being held during the exhibition. The exhibition is sponsored by the journal, *Mechanical Handling*.

MOBILE CRANE

The largest mobile crane ever built, the Colossus (L.4610), illustrated in Fig. 1 opposite, is being shown for the first time in public. It has been designed and produced by Steels Engineering Products, Limited, Sunderland. Fitted with 30-ft. jib, it will lift 92,000 lb. at 12 ft. radius.

A special chassis had to be made to carry the superstructure; this chassis has an 8-wheeled by 4-wheel drive, and all the wheels are fitted with compressed air brakes. The tyres are 14 in. by 24 in. by 20-ply singles on the four front wheels and twins on the four rear wheels. A Rover Meteorite 250-h.p. Diesel engine transmits the motive power through a tandem drive with double-reduction gear on each driven axle. The primary reduction is by worm gearing and secondary reduction by two epicyclic trains. Two 100-gallon fuel tanks, each equipped with a Duplex fuel pump, are carried on the chassis.

As can be seen in the illustration, it has a one-man cab with left-hand drive. The steering is power-assisted and there are twelve forward and three reverse speeds. The lighting and starting are both supplied by a 24-volt system. Telescopic girder stabilisers and screw jacks are fitted to the chassis.

The superstructure, which can be slewed through 360 deg., can be fitted with a 90-ft. jib of tubular-lattice construction and an additional fly jib provides a lift to over 100 ft. The power for operating the crane is taken from a variable-voltage generator driven by an 80-brake horse-power Perkins-P6 Diesel engine. The hoist derrick and slew motions are driven by separate electric motors. All the motors are fitted with electro-mechanical brakes and these operate automatically if the supply of current is interrupted. Limit switches fitted to the hoist and derrick motions stop the jib or load moving beyond fixed limits. The clearance height of the crane is 16 ft., tail radius 12 ft., wheelbase 21 ft. and the unladen weight is about 50 tons.

MULTIPLE-VALVE BLOCK

Keelavite Rotary Pumps and Motors, Limited, Allesley, Coventry, are exhibiting at this exhibition for the first time. A selection of their range of 1,500 standard pieces of equipment for use in hydraulic power transmission are being shown. Among these are fixed capacity pump-motor units, taken from a new range recently developed by this company, with displacements up to 50 cub. in. per revolution for power transmissions from fractional power-outputs to 250 h.p. at 2,000 lb. per sq. in. Each unit can function as a pump or motor in either direction of rotation without any modification in assembly.

An item of particular interest to all designers of earth-moving and mechanical-handling machinery is the multiple-valve block built up from identical sections to form a central controlling point for six separate operations. Such a valve block is illustrated in Fig. 2. Steering and relief valves may be incorporated in the same block. A working exhibit on the stand shows a valve block of this type controlling a constant-torque variable-speed rotary drive. The maker's flow-dividing equipment is used to give the synchronised movement of the out-of-balance loads employed in the drive.

NATURAL-FREQUENCY CONVEYOR

A natural-frequency conveyor, which uses springs to vibrate a trough to convey the material, is being exhibited by Redler Conveyors, Limited, Dudbridge Works, Stroud, Gloucestershire. The illustration (Fig. 3) opposite, shows the conveyor with a cover fitted over the carrying trough to prevent any dust or contamination of materials when handling foods, chemicals, etc.; one inspection hole is open, the Perspex cover having been removed. The conveyors are built in 10-ft. sections and to various standard trough widths. The speed of flow, which is based upon a $\frac{3}{8}$-in. amplitude of vibration and a normal frequency of 850 strokes per minute, is about 70 ft. per minute. The depth of material carried depends on the volume of feed, the average being about 3 in.

This type of machine is said by the makers to be one of the most economical means of conveying bulk materials. The conveying trough is supported by rocker arms, which pivot about brackets on the main frame. The lower end of the rocker carries a balance frame, which moves in opposition to the trough. Helical-coil springs, which are mounted at an angle between the trough and balance frame, regenerate most of the power applied ready to start each successive stroke. The driving motor is shown mounted above the conveying trough. It drives an eccentric through a V-belt and pulleys. Although not shown in the illustration, a protecting cover is normally fitted over the belt drive.

The wear on the trough is said to be very low. For handling abrasive materials the trough can be lined with rubber or other resistant material. Resilient rubber bushings are used for carrying the rocker arms and the only points that require lubricating on this machine are the motor bearings and the eccentric.

MANUALLY-OPERATED LIFT TROLLEY

Didsbury Engineering Company, Limited, Little Western-street, Rusholme, Manchester, are showing among other items on their stand the small manually-operated trolley, illustrated in Fig. 4. It has been designed for carrying packing cases and other similar objects weighing up to 2½ cwt. The maximum width of load that can be carried between the two side arms is 2 ft. and the minimum 7 in. Pallet trays constructed from mild-steel sheet and angle can be used for supporting and stacking small packages or irregularly shaped articles.

The load is usually carried by the lower flange of the two side angles and by the strip of angle which can be seen in the illustration projecting from the front of the carriage frame. The side arms can be lowered to the ground by pulling back on the T-shaped handle until the front castoring wheels lie flat. This enables the trolley to be pushed forward so that the strip of angle in front of the frame passes under the front edge of the load. The side arms are then moved inwards in a scissor-like action until they also support the load by pulling back the single centrally-placed lever. The arms are raised and the castors returned to their normal position ready for moving by pressing back and downward on the main handle.

The trolley is known as the " Minigrip " and is constructed throughout from mild steel. The operating lever and main handle are fitted with rubber grips and either cast-iron or rubber-tyred wheels of 8-in. diameter can be fitted.

HIGH-LOW LOADER

The Mercury Truck and Tractor Company, Limited, 19 London-road, Gloucester, are showing their Telehoist high-low loader. This truck, which is illustrated in Fig. 5, has a capacity of 2,700 lb., a loading height when raised of 138 in. and when lowered of 40 in. It has a number of applications, but in particular it is suitable for use in loading aircraft where the hatch-way is well clear of the ground. The body measures 114 in. by 66 in.

The chassis is of robust construction and is powered by a four-cylinder Perkins-P4 Diesel engine. The platform is raised by hydraulic rams, and the hydraulic pump is driven from the power take-off. A patented parallelogram linkage ensures that the platform remains in one plane relative to the ground. The two main advantages of the design are the true vertical lift and, more important, when operating near aircraft, the high degree of stability maintained at any height.

STRADDLE-TYPE FORK-LIFT TRUCK

A compact fork-lift truck known as the " Warehouser," recently introduced by the British Division of the Yale and Towne Manufacturing Company, Willenhall, Staffordshire, is being shown for the first time. The truck is illustrated in Fig. 6 on the opposite page. It has been designed to assist in stacking standard pallets of 30 in. by 30 in. and 48 in. by 48 in. in confined spaces. Made with lifting capacities of 1 and 1½ tons at a 24-in. load centre, it can have a single or telescopic lift giving a maximum height of 148 in. The 48-in. standard pallets can be stacked fully-loaded with the truck working in an aisle of 6 ft. 4 in.

The drive is provided by a horizontally-mounted motor, which draws current from a 12-volt battery which is carried on rollers in a compartment measuring 9⅝ in. by 34⅝ in. by 31¼ in. high. A hinged cover and detachable side-plate makes battery changing simple. A platform for the operator is built into the rear of the truck body and it is partially enclosed by a sheet-metal guard. A dead-man pedal for controlling the driving motor is set in the floor of the platform and the steering wheel is located above the control box. A single lever adjacent to the steering wheel controls the lifting gear. There are three forward and three reverse speeds and the maximum speed is 4·3 m.p.h.

A hydraulic cylinder fed by a gear pump driven off a vertically-mounted high-torque motor raises and lowers the forks. The balance is assisted by the outriggers which project from the front of the main body and which incorporate small roller wheels which can be either steel or rubber tyred. The height of these outriggers is 4½ in. to allow them and the lifting forks to pass beneath the pallet.

To be continued

ALUMINIUM CRANE JIBS

Longer Reach with Lighter Jib

The jetty at Purfleet belonging to William Cory and Sons, Limited, is now equipped with five 7½-ton grabbing cranes supplied by the Clyde Crane and Engineering Company, Limited, Mossend, Lanarkshire.

These cranes are being principally used for transferring bulk cargoes, such as coal, sulphur, etc., from cargo vessels into river barges. It was originally intended that all five cranes should have 80-ft. jibs of normal steel-construction, but it was found that such a length of jib would be insufficient to permit some of the larger ships, now making use of the jetty, to be unloaded directly into barges lying on the off-shore side of the ships; it was, therefore decided that two of the five cranes should have jibs 90 ft. in length.

To have used steel-jibs 90 ft. in length, however, would have resulted in an increase in the weight of the cranes and required a strengthened jetty; it was decided, therefore, to fit alluminium-alloy jibs. The two 90-ft. aluminium-alloy jibs now in use were designed and fabricated by S.M.D, Engineers, Limited, 2 Buckingham-avenue, Slough, Bucks, of the Almin group of companies, in collaboration with Mr. G. T. Shoosmith, M.A., M.I.C.E., M.I.Mech.E. and the Clyde Crane and Engineering, Company, Limited. Special bulb-angle extrusions of "Alminal W.15" (HE 15 WP) were used for the main booms and bulb-angles of "Alminal W.10" (HE 10 WP) for the bracing members. Cold-driven aluminium-alloy rivets were used throughout.

The weight of each 90-ft. aluminium-alloy jib is stated to be 2 ton 11½ cwt., as against a weight of 6 ton 13 cwt. for its 80-ft. counterpart; the longer jib, therefore, weighs less than 40 per cent. of the shorter jib of steel construction.

The jibs have not been painted, but since the high-tensile alloy HE 15 WP, used for the main booms, does not possess as good a resistance to corrosive gases in the atmosphere as does the more usual structural alloy HE 10 WP, they have been sprayed with a coating of pure aluminium approximately 0·006 in. thick. The first of the new jibs was erected in September, 1953, and the second of them in November, 1953. Both are reported to have given satisfactory service and the tonnage handled by each crane has averaged 11,000 tons a month.

WAGON-MOUNTED TRENCHING MACHINE

SELF-PROPELLED DITCHER FOR RAILWAY TRACK

Among the plant displayed at the exhibition arranged in conjunction with the recent meeting in London of the International Railway Congress was the wagon-mounted ditching machine illustrated in the accompanying picture. Designed for cutting trenches alongside the track the machine will enable, where suitable possessions of the line can be arranged, maintenance work to be carried out more quickly and with less labour than hitherto. The "Railway Ditcher," as it is to be known, has been designed by the Research and Development Division of Jack Olding and Company, Limited, Hatfield, Hertfordshire.

The ditcher is mounted on a framework resting in a pivoted cradle on a roller track which allows a full 360-deg. rotation. The vertical digging boom is a modified form of the 5 ft. 6 in. Barber Greene type carrying 22 self-cleaning buckets; normally the bucket width is 18 in., but this can be extended to 21 or 24 in. by fitting side cutters. The maximum depth of cut is 6 ft. 3 in. below rail level. The boom is extendible to any depth between this and ground level and can be quickly raised to avoid obstructions while the pre-set cutting distance from the side of the wagon is maintained.

The buckets empty on to an 18-in. cross conveyor suspended from the boom and driven by a reversing bevel box on the head shaft so that spoil can be discharged to the centre of the wagon or outside the trench. The conveyor is adjustable by means of a winch to discharge up to 6 ft. from the trench to suit the space available.

The boom assembly, engine, gearboxes, traction winch and jack shaft are mounted on framework resting in a cradle which can be swung to enable the ditcher to cut on either side of the wagon. The frame can be traversed through the cradle for a distance of 2 ft. by means of a hand-operated hydraulic jack, so permitting the centre line of the trench to be varied between 3 ft. to 5 ft. from the near rail.

When the machine is digging, the cradle is secured to the wagon floor and jacked up to relieve the load from the turntable rollers. In the travelling position the complete assembly is swung round to lie at the bottom of the wagon and within the loading gauge.

The power unit for the ditcher is a six-cylinder Perkins Diesel engine governed to 1,400 r.p.m. and developing 48 h.p. The transmission is a Ford 7V four-speed and reverse gear box and is clutch mounted on the engine, driving a 3·3 to 1 reduction gear box through a flexible coupling. The jack shaft is coupled to the reduction-gear output shaft and carries both a Reynolds friction clutch and chain sprocket driving the boom-hoisting winch, and a dog clutch and sprocket driving the bucket line. The latter is protected from overload by a spring release gear in the headshaft chain sprocket and is automatically resetting.

For travelling during operation, a worm-driven winch carrying 300 ft. of ⅝-in. diameter wire rope and mounted in the sliding frame provides the traction power. The rope can be pulled off by hand to an anchorage point and then pulled in by the winch while cutting is taking place. The winch is driven by a vane-type oil motor operated by a variable-delivery vane pump mounted on the engine, and the speed is continuously variable up to 6 ft. per minute. The winch drum is fitted with a spooling device to lay on the rope. Excessive rope pulls are avoided by a relief valve in the hydraulic system to limit the maximum oil pressure. Should it be necessary to reverse the wagon to clear an obstruction in the trench, a snatch pulley is fixed to the rail behind the wagon wheels with a quick-acting clamp and a loop of the traction rope reefed around it.

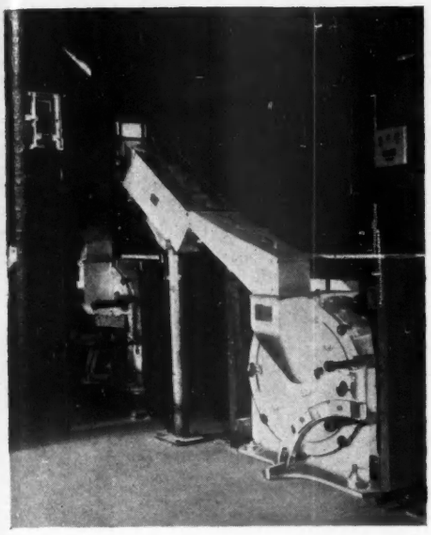
Normal output of the ditcher, cutting at its full depth of 6 ft. 3 in. below rail level, is 0·61 cub. yd. per minute when cutting a 24-in. wide trench at a speed of 1½ ft. per minute. Where conditions permit a greater travelling speed of 2½ ft. per minute, the output rises to 1 cub. yd. per minute.

The principal controls are grouped on the frame in such a position that they can be operated from a cab mounted on the boom side of the cradle. The scraper hoist and conveyor winch are mounted on the boom. The winch dog clutch is mounted close to the drum. A further control for canting the sliding frame and the digging boom in order to correct for super-elevation on curves is provided by means of wormwheels and screw jacks in the cradle, and these can raise or lower the inner support rollers of the sliding frame by 4 in.

The milling action of the bucket line enables the ditcher to cut through any type of material including bricks, rubble, etc., and still leave clean straight side walls. The trench is cleared by a close-fitting scraper located behind the bucket line which collects all loose material and returns it to the buckets. The scraper is hoisted clear during the initial cut by means of a chain winch and lowered into the trench as soon as sufficient clearance has been obtained. The scraper is secured by a spring release which will allow it to swing clear if it should foul an obstruction.

Accessories include an 8-gallon fuel tank built into the frame and semi-rotary pump with flexible hose fitted to the cradle enabling the tank to be filled while the machine is in operation. Spotlights are provided to enable the machine to be worked at night.

This wagon-mounted trenching machine, the "Railway Ditcher," can cut a trench 24 in. wide, 6 ft. 3 in. deep below rail level, at a speed of 1·5 ft. per minute. When working it is self-propelled by a mounted winch hauling on an anchored traction rope.



An example of the Velofeeder system for feeding a grinder giving automatic control of the rate of supply.

AUTOMATIC FEED FOR CRUSHERS

The Simon Engineering Group, Cheadle Heath, Stockport, have introduced an electronic control system for adjusting the supply of materials to grinding or pulverising machines. The system uses the Velofeeder, a mechanically-operated vibrating feeder, the amplitude of the vibrations of which, and therefore the rate of supply, is adjusted to the load on the crusher motor. The illustration shows a typical installation.

A current proportional to that of the main motor is fed to the controller and is used to drive a small geared motor. This, in turn, adjusts the feed-rate mechanism of the Velofeeder and so controls the supply of material. "Hunting" of the system is avoided by having a "dead-spot" between plus and minus 2½ per cent. of the full load current. It is claimed that by running at approximately full load continuously, power savings of about 5 per cent. can be made over hand-controlled machines. The equipment is designed for use in dusty atmospheres.

A NEW RANGE OF A.C. GENERATING SETS

For use in private homes and factories overseas

To provide householders, factories and other establishments, who are without mains electricity, with alternating current for lighting and power J. and H. McLaren, Limited, Airedale Works, Leeds 10, have introduced a range of Diesel-driven generating-sets. The name "Brabo" has been given to this range. The sets are being made for export only and are in six sizes: 1¼, 3, 6, 12½, 18 and 25 kW. The illustration below shows the 25-kW set with the control gear mounted above the generator.

The generators normally supplied will provide current to the standard voltage of the area in which they are to be used. The base plate on which the engine and generator are mounted has been made particularly strong to guard against misalignment.

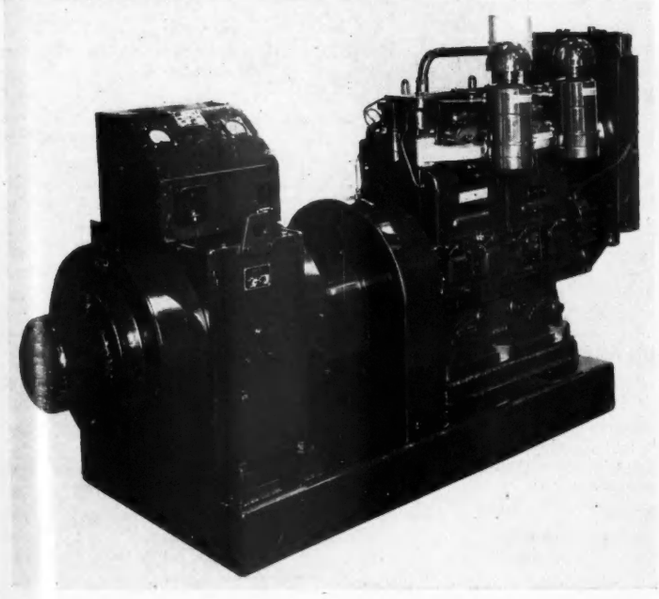
From 12½ kW upwards, the sets can be fitted with one of five types of control: hand start and remote stop, using a cranking handle for starting and a switch, usually installed in the building, for the cut-out; remote start and stop operated by switches or push buttons; fully automatic, which means that the set starts up immediately any appliance is switched on and stops when it is cut-off; electric start, remote stop, this has a local press-button starter; and automatic start, which starts the set in the event of a mains failure when being used as a standby generator.

For protection of the sets other than the hand-starting type a thermal cranking limiter has been fitted. This automatically disconnects the battery from the starter should the set fail to start within 15 seconds. A warning device automatically gives rise to a periodic reduction of voltage and light intensity in cases of overload, and when the overload is removed the set reverts to normal operation. Protection is also provided against internal or charging-circuit faults.

The prime components used in the construction of these sets are made by members of the Brush group. The square-path alternators and control gear are being made by the Brush Electrical Company, Limited, at their Cardiff Works and the engines for the smaller sets are being made by Petters, Limited, Staines. The larger engines, though of Petters design, are produced at Leeds.

The 1¼-kW set is powered by an AZ1 single-cylinder Diesel engine. The standard model is mounted on a flat bed-plate and coupled to the alternator by a flexible-coupling. It is also built as a tallboy, with the engine mounted on a 16-in. high pedestal. Beneath it is the generator driven by a V-belt. The total height of the tallboy is 45 in.

The 3-kW and 6-kW sets, which can be made with either hand start, remote start, or fully automatic, are driven by the AV1 or AV2, vertical single- and twin-cylinder Diesel engines, and the three larger sizes are powered by B2, B3 and B4 vertical, twin-, three- and four-cylinder, Diesel engines, respectively.



The 25-kW set, driven by a four-cylinder Diesel engine is suitable for mains standby. It is the largest of a new range of generating sets designed to supply current at the standard voltage of the area in which it is installed.

★ ★ ★

TRANSFORMER OIL WITH INCREASED LIFE

After four years of research work, the Manchester Oil Refinery, Limited, Twining-road, Trafford Park, Manchester, 17, have developed a transformer oil containing additives which inhibit both oxidation and the solution of copper and iron. It is therefore called "Passivated" transformer oil.

The research carried out by the firm showed that all transformer oils in current use dissolved metals to an appreciable extent. Oxidation of mineral oils is always accelerated by the presence of metals in solution, and therefore the useful life of the oils was seriously curtailed. Further work showed, by use of the Michie test, that the presence of soluble copper to the extent of one part per million doubled the sludge-forming potential of the oil.

The additives eventually produced, not only prevent the oil from dissolving copper and iron, but also render it unaffected by the presence of solutions of either metal in the form of soaps. This enables the oil to be used in existing equipment without the necessity for an absolute cleansing to be carried out first. It can be used with other oils provided that the latter do not also contain additives which will cause reactions to occur. The additives used in the passivated oil are nitrogen-containing organic compounds amounting to less than 0·25 per cent. by weight. They are not removed by mild adsorbents such as Fullers' earth or activated carbon.

The passivated oil conforms to the requirement of B.S. 148-1951, and the base oil, without the additives, complies with the specifications of most countries. It should therefore be acceptable wherever the use of inhibitors is permissible. The reduction in the rate of oxidation gives the oil a greatly increased life when used under standard temperature conditions, or, alternatively, it will give about the same useful life as other oils when the operating temperature is increased by 30 deg. F. The presence of the additives has no effect on the electrical properties of the oil.

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OIL REFINERY AT LLANDARCY

Erection begins this month of the platforming units at the Anglo-Iranian Company's oil refinery at Llandarcy, near Swansea. The concrete foundations have already been almost completed. The work, which should be fully completed by early 1955, will mark the end of the extension programme at Llandarcy. The units will produce a high-grade motor-spirit component by a reforming process employing a platinum catalyst.

Labour Notes

EFFECTS OF NATIONAL SERVICE

A special inquiry is to be conducted by the Ministry of Labour and National Service into the effect of national service upon the education and employment of young men.

The investigation is being undertaken on the advice of the Advisory Council on the Relationship Between Employment in the Services and Civilian Life, and will cover a representative section of national servicemen on their return to civilian employment.

In a written answer to a recent parliamentary question, Sir Walter Monckton, the Minister of Labour, stated that the object of the inquiry was to obtain definite information on such matters as the men's employment, vocational guidance and re-settlement.

For this purpose, national servicemen who completed their two years' training last September are being invited to go to a local office of the Ministry, where they will be asked for particulars about their pre-service employment, their work when in the Forces, and their present jobs. The details they give will be treated as strictly confidential and will be used only for the purposes of this inquiry.

Sir Walter said that it was his hope that, by this means, his Department would obtain valuable information concerning any educational or employment problems which might exist. He added that the young men concerned would be performing a most useful public service by co-operating fully in the investigation.

It is understood that men discharged in September were chosen because they included university students and others who were still continuing their education, men who left school at the age of 14 or 15 and who had had several years of employment before entering the Forces, men who had served apprenticeships in a number of trades, as well as men who had had professional training.

DEMAND FOR RAILWAY STRIKES ON SUNDAYS

A small body of footplate men's representatives from the Eastern and North Eastern Regions of British Railways decided at an unofficial meeting at York on June 10 to recommend the imposition of regular Sunday strike action at all main depots in the two Regions, as from Sunday next, as a protest against the additional lodging turns introduced in the Eastern Region on June 14.

No extra lodging turns were introduced on the North Eastern Region and it is worthy of note that the majority of the men attending the meeting came from that Region. Trade unionists from the Darlington, Gateshead, Middlesbrough, Newcastle and York branches of the Associated Society of Locomotive Engineers and Firemen, and from the Gateshead and York branches of the National Union of Railwaymen, on the North Eastern Region, were present.

So far as the Eastern Region was concerned, on which 49 extra turns came into force, the only depot to be represented appears to have been Doncaster. Enginemen on the North Eastern Region have intervened in the dispute mainly on the ground that they may be affected indirectly.

The meeting passed, by a majority, a resolution demanding that, "as a first step to the total abolition of lodging turns, this conference recommends that a Sunday strike action be called as from June 20, and continue every Sunday until the new lodging turns, due to commence on June 14, are withdrawn." A proposal for a continuous strike, as from midnight on June 20, was rejected.

Although there are some thirty thousand enginemen in the two Regions, there were only about twelve men present at the conference. They are due to meet again next Monday.

UNION'S HINT OF DISCIPLINARY ACTION

Union reaction to the unofficial meeting at York was prompt. The N.U.R. reiterated its former advice to its members, namely, that they should honour the agreements which had been made on their behalf and continue normal working. It was claimed that the members of this union present at the York meeting had not supported the suggestions for strike action.

The general secretary of the A.S.L.E.F., Mr. J. G. Baty, issued a statement saying that his executive committee had considered the recommendations of the York meeting to its branches in the Eastern and North Eastern Regions to indulge in Sunday token strokes. The committee had recorded the view that this contemplated action represented flagrant disloyalty to the union and was contrary to the decision of its 1954 annual assembly of delegates.

Mr. Baty said that the proposed action was rendered more unfortunate owing to the union's branches having been made aware, only a few days previously, of the urgent steps taken by the Society to have the total abolition of lodging turns discussed at national level.

Recognising that such suggested action was thus bound to undermine the authority of the organisation, and to prejudice the consideration of other vital matters, the committee had indicated that any disloyalty of the kind suggested would call for their serious consideration, in the event of action being taken.

WARNING OF REPERCUSSIONS

Lodging turns were also discussed at the annual conference of the National Council of Locomotive Grades of the National Union of Railwaymen at Hastings last Sunday, when it was decided at a private session that the union should press for their complete abolition.

The assistant general secretary of the N.U.R., Mr. F. S. Green, told the delegates that the union had signed an agreement providing for the working of lodging turns and said that members must stand by that agreement as long as it existed, no matter how unpalatable such action might be. He warned the conference that if agreements were not honoured there would be an end to all negotiations with trade unions.

Pleas that railway managements should recognise the feeling which existed among the men with respect to these turns of duty were made by Mr. Idris Williams in his presidential address. He claimed that the existing situation was due entirely to the attitude of the railway managements and the Government, which were concerned too much with economies and too little with the conditions of the men. He said that when the railways were nationalised, the men hoped for a period of co-operation and mutual assistance between the managements and themselves, but, after seven years, there was a feeling of frustration and disappointment.

SUGGESTED REDUCTIONS IN HOURS OF WORK

Unanimity was reached last week by the resolutions committee of the International Labour Organisation's conference at Geneva that the Organisation should consider the initiation of measures for the general reduction of hours of work. The committee comprises representatives of Governments, workpeople and employers, and recommendations to give effect to these suggestions were due to be considered by the main body of the conference during the past few days.

It is proposed that the governing body of the Organisation shall instruct the director-general to draw up a report on working hours at present in force in the countries represented and what results a reduction in hours might be expected to have on their individual national economies.

With such a report before them, the governing body could examine the whole subject and consider what further action might be taken to examine the question on a tripartite basis. The matter came before the resolutions committee after motions had been submitted by workers' delegates from Switzerland and Italy.

EMPLOYMENT STATISTICS

Employment exchanges of the Ministry of Labour filled 733,000 vacancies in Great Britain during the 12 weeks ended May 5. During the corresponding period last year, 748,000 vacancies were filled. The number of vacancies notified to the exchanges, but still unfilled at May 5, was 330,900. This was 49,700 more than a year previously.

EMPLOYEES' LIVING STANDARDS

Demands that the Trades Union Congress should adopt a policy which would provide for a continuously rising standard of living for all employees were made at the week-end conference of the Association of Supervisory Staffs, Executives and Technicians at Brighton.

The delegates unanimously adopted a resolution calling upon their executive council to prepare a case for such a policy and to submit it in the early future to the T.U.C. General Council.

Supporting the resolution, the union's general secretary, Mr. H. G. Knight, said that there was a tendency at the present time to think in terms of national prosperity and to overlook those who had produced it. He claimed that, although living standards had definitely improved during the last fifty years, the proportion of the national income paid out in wages had risen by only 2 per cent.

The conference protested against "statements made by leading officials of a few trade unions opposing wage increases." Such statements, it was affirmed, did not express the views of trade unionists generally. The union has a membership of about fifteen thousand.

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NOTICES OF MEETINGS

British Road Federation

LONDON
"The Development of a Modern Highway System," by Dewitt C. Greer. Royal Empire Society's Building, Craven-street entrance, W.C.2. Mon., June 21, 6 p.m. (By invitation: tickets obtainable from the Federation.)

Incorporated Plant Engineers

LIVERPOOL
"Economy in Process Steam," by H. E. Lake. Merseyside and North Wales Branch. Radiant House, Bold-street, Liverpool. Mon., June 21, 7.15 p.m.

Institute of Metals

LONDON
"The Brittle Fracture of Metals: Some New Developments," by Professor E. Orowan. Wed., June 30, 5 p.m.

Institution of Highway Engineers

LONDON
"Texas Expressways," by Dewitt C. Greer. Royal Automobile Club, Pall Mall, S.W.1. Thurs., June 24, 5.30 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

British Road Federation, 4a Bloomsbury-square, London, W.C.1. (HOLborn 3345.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of Metals, 4 Grosvenor-gardens, London, S.W.1. (SLOane 6233.)
Institution of Highway Engineers, 47 Victoria-street, London, S.W.1. (ABBey 3891.)